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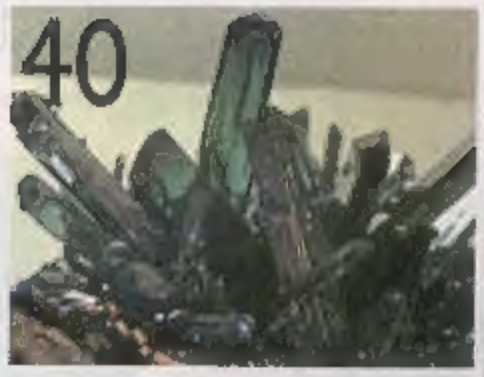

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ON THE COVER

These California gold specimens owned by Kristalle, Laguna Beach, show various types of crystallization, including octahedrons, leafs and wires. (Photo by Harold and Erica Van Pelt)

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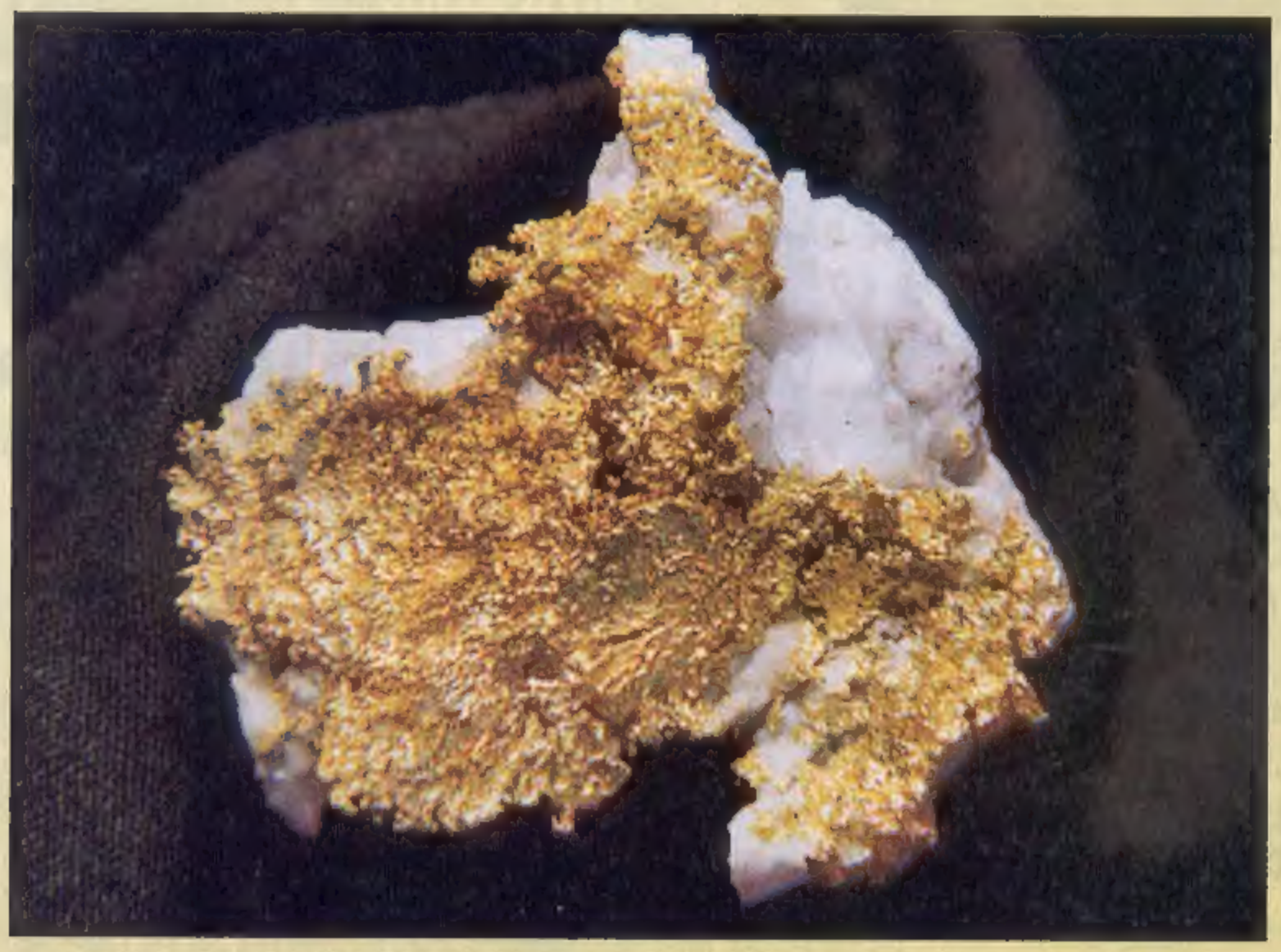
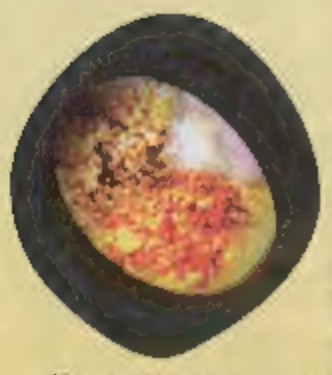
Gold of Many Colors

Alloys Produce New Shades and Properties

Story and Photos by Steve Voynick



Though the rich color of this California gold-on-quartz specimen suggests purity, it is only 90 percent pure.



f gold's many unusual properties, its unique color may be the first to come to mind. The universally familiar color of pure gold—a metallic yellow warmed by just a hint of orange—is shared by no other metal. But with the exception of investment bars, bullion coins, and special heirloom forms of jewelry, the average person sees little pure gold. The gold in most jewelry and in all our mineral specimens is alloyed with at least one and usually several other metals.

If gold is such a remarkable metal, some might ask, why do we have to alloy it at all? Alloying gold serves a number of purposes. Because the metal is very soft when pure, alloying increases its hardness, and thus the wearability of gold jewelry and the durability of gold coinage. Gold is also alloyed to alter its color and to create specific mechanical and electrical properties.

Gold alloys are rarely the same color as pure gold because the introduction of other metals imparts subtle to extreme color shifts. Combining gold with other metals to create alloys with specific colors and acceptable mechanical properties is not simply a process of mixing metals,

but a specialized and increasingly complex metallurgical subscience.

The two metals most commonly alloyed with gold are silver and copper. Other familiar gold-alloying metals include palladium, platinum, nickel, and zinc. But many metals you might not think of are also alloyed with gold, among them iron, aluminum, cobalt, manganese, iridium, titanium, calcium, and even certain rare-earth metals. All these metals create alloys with widely varying mechanical properties and colors ranging from the warm yellow of pure gold to white, green-yellow, pale yellow, rose, pink, and even blue and purple.

The story of gold alloys begins with native gold, which is itself an alloy. Native gold always contains quantities of other metals, most often silver and copper. Its purity is usually no higher than 95 percent and, in the case of electrum, a natural gold-silver alloy, as low as 50 percent. Some specimens of native gold have a rich yellow color similar to that of the pure metal, while others have a reddish tint indicative of high copper content. Still others are paler shades of yellow.

But color is a poor indication of the approximate purity of native gold or of the identity of its alloying metals. Even when native gold is heavily alloyed with roughly equal parts of silver and copper, its color can approximate the rich yellow of pure gold. Conversely, native gold only lightly alloyed with nickel is a pale yellow that would seem to indicate low purity.

When it comes to creating colors, alloying metals cannot be compared to, say, the mixing of paints. Mixing paints merely combines reflective pigments to produce a predictable result. Alloying, however, alters the basic atomic structure of the metal itself.

Metals are defined as elements that are crystalline in structure, solid at room temperature (mercury is an exception), opaque except in thin films, and electrically conductive. They consist of regular arrays of atoms that are ionized through the loss of one or more electrons. These free electrons distribute themselves throughout the metallic mass as a shared-electron pool that forms nondirectional metallic bonds with the positive metal ions. Metals are good electrical conductors because their electron pool is delocalized, meaning that individual electrons are not bound to single atoms, but move freely throughout the metallic mass, thus facilitating electron flow.

Black Hills gold features rose, green and yellow low-karat gold alloys.

he Amerindians of Colombia produced tumbaga, a reddish copper-gold alloy with good casting qualities.

The warm color of this Colorado gold specimen is produced by its high copper content.

Crystallized gold from Montana has a very pale yellow color due to its high silver content.

Metals crystallize in one of three systems. Most are cubic; a few are hexagonal or tetragonal. Cubic-system metals may be face-centered or body-centered, terms that specifically describe variations in the cubic structure. Gold is a face-centered cubic metal with close atomic packing, an arrangement that, together with its high atomic weight, accounts for gold's high density (specific gravity 19.3). Nondirectional metallic bonding enables face-centered cubic crystals to slip or displace easily within the lattice, accounting for gold's softness, great malleability, relatively low melting temperature, and excellent overall workability.

The color of metals, like that of all materials, is determined by absorption and reflection of light. White light, which is the visible portion of the electromagnetic spectrum, consists of frequencies perceived as colors grading from violet to blue, green, yellow, and red. In metals, the manner in which light interacts with the free-electron pool is explained by the "band-gap" theory.

Band-gap theory posits that electrons in a metal's free-electron pool occupy distinct orbitals, or energy levels. When energized, these free electrons are boosted to a higher level, or band. The energy difference between the original band and the energized band is called the band gap, and it is specific for different metals. When energized electrons return to their original level, they emit absorbed energy at specific frequencies that depend upon band-gap width.

After light strikes the surface of gold, its energized free electrons fall back to their original level by emitting electromagnetic energy in the frequency range of yellow, the reason we perceive gold as yellow in color. When white light strikes copper, the energized electrons emit electromagnetic energy in the frequency range of red. Of all the metals, only gold, copper and bismuth, with a faint pinkish tinge, have colors other than neutral white or gray. Silver is the whitest and most reflective of all metals because its energized electrons release virtually all their absorbed energy evenly in frequencies across the entire visible spectrum.

continued on next page

Gold of Many Colors *from page 13*

Alloys are combinations of two or more metals, or of a metal with certain nonmetals such as carbon (as in carbon steels), that form solutions or intimate mixtures. Because alloying introduces metal atoms of different sizes and electrical properties into a lattice, it distorts basic crystal structure, modifies metallic bonding, and affects band-gap energies within the free-electron pool. This results in color shifts and modifications of mechanical and electrical properties.

Metals have varying degrees of mutual affinity, which is an important consideration in alloying. Those with the greatest affinity for gold are silver and copper, which share a close chemical similarity. Gold, silver and copper, which fall into the same column (1b) of the periodic table of elements, all have single outer electrons, a +2 ionic charge, face-centered cubic structures, and similar atomic radii (sizes). These similarities enable silver and copper to slip easily into the gold lattice with minimal distortion. While gold-silver, gold-copper, and gold-silver-copper alloys are harder and less malleable than pure gold, they are still quite workable.

Adding silver to gold predictably produces whitened, or "bleached," alloys with paler shades of yellow. Yet, certain other white or gray metals have a much greater whitening effect. As an example, a 22-karat gold-silver alloy with a ratio of 91.7:8.3 still has a rich yellow color and good workability. But a gold-nickel alloy in the same proportions is almost white. Furthermore, the gold-nickel alloy has considerably greater hardness, a much higher melting point, increased brittleness, and decreased workability. This is because nickel, unlike silver, substantially disrupts the gold lattice, while modifying the metallic bonding and the properties of the free-electron pool.

Metallurgists consider alloying gold to be a trade-off, meaning that they can create a specific color at the expense of workability, or they can produce an alloy with excellent workability, but not in a precisely desired color. Not surprisingly, most modern gold alloys, if they are to offer the best possible balance of desired color and acceptable workability, contain two, three, or even four alloying metals.

The first goldsmiths were concerned not so much with alloying as with purifying the metal. They learned to remove such metals as copper, silver and iron. Around 600 B.C., metalworkers in Lydia (now western Turkey) minted the world's first coinage from natural, pale-yellow electrum with an approximate 70:30 gold-silver composition. But after learning to separate the silver, the Lydians minted their coinage in nearly pure gold.

About 500 A.D., pre-Columbian AmerIndian gold workers in what is now Colombia began making tumbaga, a 2:1 copper-gold alloy with a rich, reddish color and superb casting qualities. They then gilded tumbaga castings with simple organic acids to create gleaming surfaces of pure gold atop the copper alloy. Later, when Spanish conquistadors demanded golden tribute from these conquered tribesmen, they often received gilded tumbaga.

But Spain's adventures with gold alloys were just beginning. Colombian placers often yielded gold that was heavily alloyed with platinum, a dense, white metal with a high melting point. Because platinum had poor workability and no uses, the Spanish considered it worthless. After purifying the Colombian gold, the Spanish discarded the platinum.

Gold alloys are developed as much for their practical uses in industry as for their visual appeal.

Although platinum had no uses at that time, it had interesting gold-alloying characteristics. Even in large amounts, it did little to whiten gold's yellow color, a property that, together with its high density, made it a perfect gold-counterfeiting agent. Spanish mint workers would cleverly alloy discarded platinum into gold-coinage metal, then pocket the displaced gold. In 1731, the Crown secretly ordered the debasement of its own gold coinage with still-worthless platinum, using the debased coins to pay off foreign debts.

By the early 1800s, European and American goldsmiths were routinely alloying gold with large amounts of copper to increase hardness and wearability. A few decades later, as world gold-coin production rose sharply, nations that had previously minted pure-gold coins began turning to gold-copper alloys. These alloys usually contained 90 percent or 91.7 percent gold, with copper and often a bit of silver added to increase hardness, while maintaining a classic golden color.

Also during the 1800s, jewelry alloys were standardized through the introduction of the 24-part karat system of gold purity, in which "24-karat" defined pure gold, while "12-karat" referred to a 50:50 alloy of gold and alloy metal(s). Popular alloys included 10, 12, 14, 18, and 22 karats.

By the early 1900s, platinum was gaining great popularity as an art nouveau-style jewelry metal. Jewelry demand, coupled with high industrial demand for platinum catalysts, drove platinum's price well above that of gold, then fixed at $20.67 per troy ounce. The difficulty in fabricating platinum further boosted the soaring cost of platinum jewelry. By 1920, platinum had largely been priced out of the mass jewelry market.

The need for an affordable precious metal to capitalize on the white-metal jewelry trend led to development of "white gold," a workable gold alloy with a white color resembling that of platinum. A high-karat white gold required a primary alloying metal with much greater whitening ability than silver. That metal was nickel. But nickel, while a very effective whitener, also produced brittle alloys with poor workability. So while 18-karat, nickel-based white gold typically contains 75 percent gold and 14.5 percent nickel, it also contains 5.5 percent copper and 5 percent zinc. Nickel is the whitener, while copper decreases brittleness. Zinc, a hexagonal close-packed metal, contributes to whitening and alters the gold lattice in a manner that aids the assimilation of nickel.

Besides being a powerful whitener, nickel is also very inexpensive. But on the downside, nickel in jewelry can cause a dermatitis-type rash in some individuals with sensitive skin.

An alternative whitener is palladium, a platinum-group metal with a face-centered cubic structure that alloys readily with gold. Typical palladium-based, 18-karat white gold contains 75 percent gold, 18 percent palladium, 5 percent silver, and 2 percent copper. Unlike nickel, palladium is nonallergenic and does not increase brittleness. But it lacks nickel's powerful whitening capability, has a high melting point that decreases workability (hence the need for copper and silver), and often costs more than the gold itself.

The white gold manufactured in the greatest quantity was never used in jewelry. This alloy, which few people ever saw despite its widespread use, was formulated in 1935 by Western Electric, the manufacturing arm of AT&T. Simply called Gold Alloy No. 1, it was a very pale yellow and consisted of gold, silver and platinum in a 69:25:6 ratio. Designed for hardness, durability, and high electrical conductivity, it coated the switching contacts of all AT&T and Bell Systems telephones, electrical relays, and repeaters for the next 45 years.

continued on page 16

Gold of Many Colors *from page 14*

Most nickel-based white gold is plated with palladium, platinum, or rhodium (another platinum-group metal) to create a bright, white appearance and provide some protection for those susceptible to nickel dermatitis. Due to high plating costs, metallurgists currently seeking cheaper alternatives to nickel are testing the whitening effect of manganese, chromium, cobalt, iron, and tin. But because all these metals seriously compromise workability, copper and silver will doubtlessly remain part of any new white-gold alloys.

Varying gold-alloy colors are a feature of "Black Hills" jewelry. This "tri-color" style utilizes contrasting colored alloys in grape-cluster and -leaf designs using low-karat, green- and rose-colored gold mounted on traditional yellow gold. Fourteen-karat rose gold typically consists of 58.5 percent gold, 32.5 percent copper, and 9 percent silver. When the silver in the copper-silver balance of this alloy is increased, the color shifts from rose to pink.

Although silver initially whitens gold, if added in sufficient quantity and with only minimal copper, it will also impart a subtle hint of green. Fourteen-karat green gold usually contains about 40 percent silver with a very small amount of copper. The colored gold in Black Hills-style jewelry is heavily alloyed and rarely higher than 14 karat. Most is actually 10 karat or 12 karat, because low-karat gold contains greater proportions of the alloying metals needed to create the desired colors.

Not content to limit colors to roses, pinks, greens, whites, and yellows, metallurgists are also producing exotic blue and purple gold alloys. Blue gold is a 75:25 (18-karat) mix of gold and iron. This alloy has a few specialized industrial applications, but only limited use in jewelry, as it is too brittle for most conventional metalworking applications.

Purple gold, an 80:20 gold-aluminum alloy, is a radical color departure from all other gold alloys. Because of a big difference in atomic size and a higher ionic charge (+3), aluminum greatly alters the gold lattice, metallic bonding, and band-gap energies. Although its color is a striking, bright, electric purple, gold-aluminum alloys are unworkably brittle and cannot be fabricated into traditional jewelry forms. Instead, the alloys are crudely formed, polished, and mounted in pendants.

Gold-titanium alloys, long used in certain industrial applications, have recently been spun off to jewelry use, not so much for their color as for their great hardness. Eighteen-karat, high-titanium gold alloys, which have a dark yellow color and are by far the hardest of all gold alloys, have been fabricated into watch cases. One drawback is that the alloy is so hard that it is difficult to polish. Another is that titanium, with its very low density (specific gravity 4.5), noticeably decreases the expected heft of the gold alloy. Gold-titanium alloys are also electroplated onto some jewelry items to provide a scratch-resistant gold finish.

Finally, the relatively new technique of microalloying—the addition, in very low amounts, of such alloying metals as calcium and the rare-earth metal cerium—can preserve the color of pure gold while substantially increasing its hardness. Because the amount of microalloying metal present is so low, sometimes only a fraction of a percent, these gold microalloys can also be marked "24 karat."

While such alloying agents as titanium and calcium can impart interesting properties to gold alloys, they greatly complicate the alloying process itself. Because of their high level of chemical activity, alloying and fabrication processes must be performed in oxygen-free environments.

Creating specific colors or acceptable mechanical properties are not the only considerations in alloying gold. Many alloys require small amounts of such deoxidizing agents as silicon or zinc to lend chemical stability to base metals when working at high temperatures. And the addition of small amounts of such grain refiners as iridium or cobalt can improve the casting qualities of many gold alloys.

Gold alloys have come a long way since they were first made with silver and copper. While silver and copper will likely remain the primary gold-alloying metals, many other metals, in virtually limitless proportions, are being squeezed into the gold lattice to create unusual and fascinating colors, along with useful mechanical properties. With better understanding of metal crystallography and the atomic interaction among alloyed metals, along with growing experience in alloying metals with little apparent mutual affinity, some of the most interesting colors and properties of alloyed gold are, perhaps, still to come.

Shop Talk

William A. Kappele

Sandblasting

Mention sandblasting to most people, and they will likely conjure up a vision of a huge, noisy, dusty machine removing graffiti from a concrete block wall or stripping paint from a giant earthmover. Most would never dream that a process that can accomplish such large-scale tasks can also be used to etch intricate designs in glass and on stone, but it is true. The giant sandblasters have some dainty cousins no larger than a pencil. And while the big boys need very big air compressors to power them, some of the little guys can be operated by a can of compressed air the size of a soda can.

In referring to these small units, the term sandblasting is a little misleading. More often, the media used will not be sand, but glass beads, walnut shells, ground corncobs, or even baking soda, among others. You may wonder what a lapidary or jewelry maker can do with such a device. Here are a few things.

If you are one of the many who like to build your own machines from odds and ends, or if you like to find used machines and rebuild them, a small sandblaster is the best and neatest way to get rid of that old paint, rust, and corrosion and to leave a beautiful, clean surface for new paint. If you are a caster, blasting is a great way to get investment out of those little nooks and crannies. If you are a silversmith, you can put a variety of frosted finishes on your work with little effort. If you are a carver, you can remove material rapidly by sandblasting and complete the detail for your Foredom. If you ever dabble in glass, the sky is the limit with sandblasting. You can etch and carve with amazing detail. Everything from beautiful, delicate crystal pendants to handsome monogrammed goblets is within your grasp. Are you ready to give it a shot?

Before you get out your platinum card, mortgage the old homestead, or sell one of the kids, I suggest you visit the local library, your favorite bookstore, or that repository of all things interesting, the Internet, and look at some of the work that can be done with sand blasting. If these investigations leave you wanting to get started, you will first have to decide what equipment you will need. As with most hobbies, you can spend a fortune or you can build a lot of the stuff yourself. The good news is that there are only three basic pieces you will need.

First is the gun, or handpiece, second is an air source, and third is some sort of box or cabinet to contain the blasting media. The bad news is that there are a bazillion sizes and types of these things on the market. This is just one more reason for hitting the books or the Internet sites.

If you just want to do some jewelry burnishing or frosting, clean up some investment from castings, and do etching on glass or crystal, one of the little sets that includes a gun the size of an airbrush and gets its air supply from a small canister can be had for around $50.

The process of etching is fascinating all by itself. The idea is to spray the abrasive media on the glass or crystal through a stencil made of a material that is resistant to the abrasive. Many kinds of tape, rubber cement, etc. have been used over the years, but a material called photoresist seems to be the favorite today. Where the old-style materials required the design to be cut by hand, photoresist makes it possible to create the design on a home computer, even using photographs as the pattern. This method will allow you to blast lines as fine as .003 inch. Sound like fun? I can't wait to try it.

Gather up the necessities and blast off!

Please feel free to contact me if you have a suggestion or comment about this or any of my Shop Talk columns. My e-mail is quappelle@cox.net, or write to me at 25231 Pericia Dr., Mission Viejo, CA 92691.

Alaska's first GOLD RUSH

Juneau Struck Gold 18 Years Before the Klondike

Story and Photos by
Roger McPherson

When people think about Alaska gold rushes, most envision the early discoveries around the Yukon River, the great Klondike rush to the Yukon Territory just across the Alaskan border, and Nome. Soon after the California rush, however, prospectors worked their way along the northwest coast, finding gold placers on the Frazer River in southern British Columbia, the Cariboo in central British Columbia, and up the Stikine River at Telegraph Creek in an area known as the Cassiar in the 1860s. From the town of Wrangell at the mouth of the Stikine River, prospectors went north along Alaska's southeastern panhandle of thickly forested islands, finding placer gold at Sumdum and Windham Bay in 1870 along a 100-mile trend later known as the Juneau Gold Belt.

"We were 18 years before the Klondike," Mary Pat Wyatt, curator of the Juneau-Douglas City Museum, said while standing by a time line in the museum's mining display room. "Juneau was the largest town in Alaska at that time. The prospectors would work here in the winter and then go off to the Interior to prospect."

continued on page 22

Waste rock from the Alaska Juneau mill was dumped in the Gastineau Channel and used to extend the shore.

Mary Pat Wyatt curates Juneau's City Museum, which has exhibits about early life in that gold town.

Alaska's First Gold Rush *from page 20*

Around Sitka, formerly the headquarters for Russian fur-trading activities on the Pacific Ocean side of Baranof Island, a few small hardrock gold mines were milling gold ore in the late 1870s. John Muir had canoed through the region with the help of Tlingit Indians, examining and writing about the glaciers. In a San Francisco newspaper interview in early 1880, Muir commented favorably on the mineral potential of the mainland.

A Sitka storeowner grubstaked Richard Harris and Joe Juneau to prospect the coastal belt north from the new discoveries at Windham Bay. Accounts differ about the character and reliability of these two prospectors. One story has the men spending their grubstake on alcohol and partying in a Tlingit Indian village. They were too drunk to notice their canoe drifting off with the tide. With help from Chief Kowee of the Auke Bay Tlingit, they obtained another canoe and were shown where to find gold at Gold Creek, the future townsite of Juneau.

Following up the creek, they entered Silver Bow Basin, named after Richard Harris' home area of Coeur d'Alene, Idaho. Here they discovered the source of the gold-bearing quartz. After staking several lode and placer claims on what became the Alaska-Juneau Mine, they packed out 1,000 pounds of ore. Loaded with their sacks, the men went south to Sumdum rather than directly back to Sitka to their patron. An Indian accompanying the prospectors told another miner about the rich ore in the canoe, and he figured the men were headed south to Wrangell and Victoria, British Columbia. He forced Harris and Juneau at gunpoint to return to Sitka to report to their partner.

News of the strike brought about 40 miners to the beach at Miners Cove, site of present-day Merchants Wharf in downtown Juneau, by late 1880. Mining the beach sands was the main activity until the snows melted in Gold Creek and the Silver Bow Basin the next spring. The town of Juneau had begun, although it was first named Harrisburg.

Many waterfront homes have been built along the protected shore of Auke Bay, north of Juneau, since those days when gold seekers first disturbed the native Tlingit Indians. In the Auke Village Recreation Area, the cedar-plank houses are gone and sleek canoes are no longer pulled up on the gravel beach. On foggy days, the calls of the ravens still echo from the Sitka spruce, and a totem pole honors the former village. Tlingit Indians continue to be a powerful influence in this region, but they did not benefit from the sudden influx of prospectors and businesses.

"Juneau's mining quickly changed from placer—rockers and sluices—to hardrock," explained Wyatt. "People raised money from bigwigs in San Francisco. There were three big mining companies. Treadwell was one of the first."

While miners worked the deep gravels of Gold Creek and its tributary streams and gulches, gold was also discovered across the channel at tidewater on Douglas Island. Pierre Erussard, a French-Canadian prospector, had two claims along the shore that had low-grade gold in the quartz. "French Pete" as Erussard was known, sold his claims

Pilings from the Treadwell Club are all that remain the after the Treadwell Mine caved in and fire destroyed the mine buildings.

to John Treadwell, who was disappointed with prospects he had found for his San Francisco backers. Treadwell took 22 sacks of rock from one claim and was surprised when the assays showed an ounce of gold to the ton. These claims were to grow into the highly successful Alaska Treadwell Gold Mining Co. by 1889.

The Juneau hardrock mines were the largest low-grade operations in the United States until 1941. The Treadwell group included the Treadwell, 700-Foot, Mexican, and Ready Bullion mines and five mills. These mines were next to each other along the shore on Gastineau Channel, facing east to the mainland and Juneau. Behind Juneau and up Gold Creek were the other two big mines: the Alaska Juneau, or A-J, and the Perseverance Mine. Each of these great mines had its period of dominance between 1900 and 1941, helping Juneau take the state capital away from Sitka. Other gold mines would be developed along the Juneau Gold Belt, from Berner's Bay 50 miles to the north to Windham Bay to the south.

"They consolidated and consolidated," Wyatt said, pointing to a wall display about the major companies. "The Alaska-Gastineau evolved into the Alaska-Juneau. Before that, there was the Perseverance, and it merged with the A-J."

The Treadwell Mines extended along the shore of Douglas Island for 7,000 feet and were essentially all in the same type of altered, crushed and veined rocks. Open pits or glory holes characterized the early operations, and when these became too deep for safe mining, shafts accessed the underground areas. The Treadwell Glory Hole was the largest pit, reaching a depth of 450 feet and having very steep walls. The last open pit ceased operation in 1906.

Walking trails from South Douglas wind through the rainforest fronting the sandy beach where the Treadwell complex was situated. The city museum has a walking tour and a historic guide brochure showing the locations of the important buildings along the trail. Ghostly concrete shells covered with vegetation are reminders of this famous mine. The glory hole is located uphill at the end of a wide trail. A cascading waterfall streaks down one of its vertical walls before plunging into an emerald pool. Along the beach of tan sand made of crushed mill rock, rows of pilings mark the site of the Treadwell Club.

By 1899, the Treadwell Mines had 880 stamps crushing the ore. The deafening roar of the stamps went on day and night. In addition to the machine shop, carpenter shop, sawmill, foundry, power plant, assay office, and other support facilities, the company furnished mess halls, bunkhouses, and cottages with modern conveniences. Miners were members of the Treadwell Club, which had a gym, swimming pool, bowling alley, poolroom, library, and reading room with subscriptions to more than 150 newspapers and magazines. Miners worked eight-hour shifts and were paid, on average, $100 a month, from which about $30 was deducted for room and board, medical care, and the Club membership.

The Treadwell was a pioneer in low-cost mining methods. Large chambers, or stopes, were blasted and mined using chutes to load the ore by gravity into ore cars. After 1911, the ore from all four mines was trammed to a central coarse crushing plant. From there, the ore was taken back to the mine it came from for fine crushing in stamp mills and treatment at a cyanide plant. By 1915, there were 960 stamps crushing 5,000 tons of ore a day.

The value of the Treadwell gold varied from the surface to the deepest workings, richer in some levels and less so in others. Three types of ore were identified: quartz, brown ore, and mixed ore.

Gold Creek, source of the Juneau-Harris gold discovery, is confined by a concrete channel in town.

The main ore was "quartz," a network of quartz veins and calcite in altered diorite, an igneous rock. "Brown ore" was mineralized slate that had been altered by solutions with sulfides, mainly pyrite. The "mixed ore" was a combination of the Treadwell slate (a black phyllite) intruded by small fingers of diorite and saturated with minute pyrite cubes. About two-thirds of the ore was free-milling, allowing capture of the gold with mercury. The concentrates containing sulfides with gold were sent to a smelter in Tacoma.

continued on next page

The Juneau-Douglas City Museum has dance cards from a cyanide plant ball with verses and cartoons that explain the whole process

"The rock is blasted
with giant powder,
and broken with hammers,
deep in the hills,
Whence hoisted by buckets
to the surface,
'Tis trammed in cars
to the various mills"

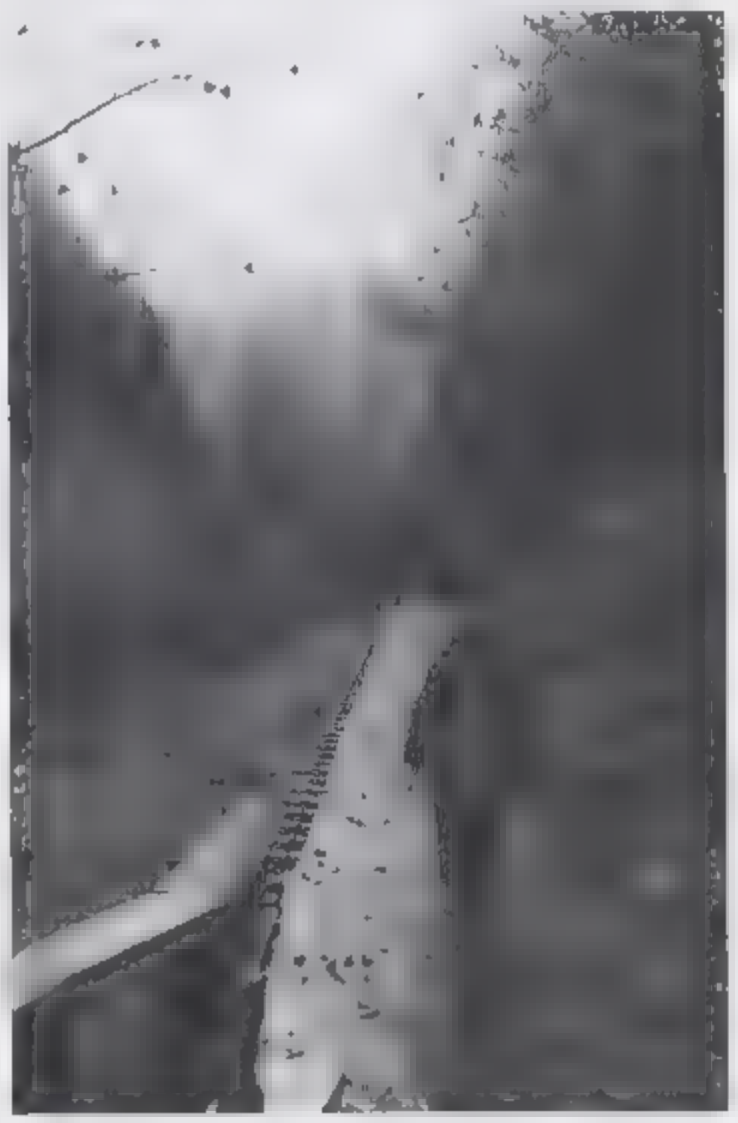
Since the mine workings were below sea level and the large stopes were only held up by pillars, subsidence and caving were inevitable. Cracks began appearing on the surface in 1916. The salt content of the water being pumped out of the mines began to increase, indicating inflow from Gastineau Channel. A three-year plan of bulkheads, filling open stopes with tailings, and other measures was begun, but too late. The ore below the 2,300-foot-level in the Treadwell Mine contained less gold. Some of the richer pillars were mined from other levels, increasing the instability of the workings.

The Treadwell caved in on April 20, 1917, leaving a huge hole. The tide rushed in, filling the Treadwell, Mexican, and 700-Foot mines. The men got to the surface safely, but the horses, mules, and equipment were all lost. The Ready Bullion Mine was saved by a concrete bulkhead, and it continued operations until 1922, when the ore became too lean. In 1928, the mine properties were sold to the Alaska Juneau Gold Mining Co. The mines had made $67 million from 3.2 million ounces of gold, and employed nearly 2,000 men during their peak years. Ambitious plans in the 1930s to tunnel beneath the mines were abandoned, and little of the industrial complex remained after a 1926 fire except for the Treadwell glory hole and cave-in pool by the beach.

Meanwhile, deposits in the mountains behind Juneau had been accessed by a road and trails up Gold Creek, and seasonal operations gradually became year-round. For a while, placer mining in Gold Creek and the Silver Bow Basin was the principal activity. By 1890, hill and gulch placers exploiting decomposed gold-bearing rocks below the Alaska-Juneau and Perseverance mines were worked out.

The Nowell Gold Mining Co. dug a 3,000-foot tunnel under the Silver Bow Basin and washed gravels from 1891 until 1902. Two hydraulic giants sent gravels into a flume in the tunnel, mining down 100 feet and creating deep pits in the valley. Mineralized quartz boulders were sent down the tunnel to a small mill for crushing. A tunnel had also been run under the shallow gravel of upper Little Basin in 1888, and it produced about 2,400 ounces of gold. In the 1906 USGS Bulletin 287, a discussion of the possibility of working the deeper gravels of the Little Basin placer, Arthur C. Spencer commented, "If it is ever worked, an elevator must be installed."

The mouth of Gold Creek at tidewater created an extensive delta deposit containing fine gold derived from the glaciers and stream outwash. A mile upstream was the Last Chance, or Jualpa, placer, extending for three-quarters of a mile and filling in the first of three basins. Glacial gouging, moraines after the glacier melted, landslides, and changes in stream gradient created these basins. Today, the Last Chance Mine offers tours of its buildings in the summer. Trails lead on up the valley to the Perservance Mine and Ebner Adit. A walking trail on top of a wooden flume beside Gold Creek is a popular way to visit the valley from Juneau.



A hiking trail was built on top of a flume along Gold Creek. Other trails lead to mine sites

On the north flank of Gastineau Peak, facing the Silver Bow Basin, the Perseverance Mine grew into another high-output, low-grade hardrock mine. It was created by the Alaska Gastineau Mining Co. when its manager, Bartlett Thane, consolidated various properties and began a series of engineering projects in 1912, including a hydroelectric plant, a large mill on Gastineau Channel, a 3.5-mile railroad, and the Sheep Creek Adit, a 10,500-foot tunnel under Mount Roberts to the millsite. The mill was designed after the model of Utah Copper at Bingham Canyon, where dry ore was crushed on a large scale. With the capacity to treat 6,000 tons of rock a day, the mill at the company town of Thane would process more than the Treadwell mines. By 1915, the mill was operating and the value of the stock quadrupled to $40 a share.

Although a camp with living quarters was built in the mountains at the Perseverance Mine, the main mill camp was at the townsite of Thane, three miles southeast of Juneau along the shore beside Sheep Creek and almost directly across the channel from the Treadwell mines on Douglas Island. Mill employees lived in a small town that had 50 houses, a two-room school, meat market, bakery, general store, gymnasium, and library. A few miles up Sheep Creek Valley was the portal of the adit from the mine, and further back in the mountains were the Salmon Creek dam and Annex Lake hydroelectric plant.

Problems soon surfaced, the worst being the low grade of the ore—just over $1 a ton rather than the hoped-for $2 a ton. A higher-grade body was located, but it was still not enough for a profitable operation. In addition, schist in the high-grade area would cave into the ore being mined, reducing the grade even more. Hand sorting wasn't used, all the rock that was mined was taken by railroad through the tunnel to the mill and crushed. World War I reduced the available manpower, and water began flooding into some stopes, making the ore too wet for efficient milling. After only nine years of operation, the mine and mill complex closed in 1921. Called a "successful failure," the Alaska Gastineau had accomplished engineering marvels, but the mine just never efficiently processed enough of the low-grade ore to make a profit. In 1934, the holdings were sold to the Alaska Juneau Gold Mining Co. and were connected underground with the A-J Mine. By 1943, the Perseverance ore made up 70 percent of all ore mined in the A-J. The mine was closed from 1944 until 1986, when Echo Bay Mines reopened the Sheep Creek Adit and evaluated the deposit.

"After 70 years of lying there, we had to muck out the rocks and clean it up," Jerry Harmon, Alaska Gastineau Mill and Gold Mine manager, explained as he drove an Airporter van up the switchback road above Thane. His neatly

trimmed silver beard and reddish cheeks gave this burly hardrock miner a Saint Nick look. "I worked at this mine 17 years for Echo Bay," he said.

The company invested $150 million to open up the mine and evaluate it, but environmental issues prevented the mine from returning to production. Today, the whole complex, from its portal and underground workings down through its mill and ore chutes, gives visitors an inside look at how the mine once functioned. Tours take place daily from June 1 to October. Contact Princess Tours in Juneau at (907) 463-3900 or visit www.ptoursinc@aol.com.

"We follow the flow of the gold from the mine down," Harmon said as he drove. "This mine produced 10,000 tons of ore a day. For every 16 tons of ore, they produced one ounce of gold." One muscular arm swept around in an arc as he spoke. "We deal with history here — no Disneyland. We have signs and historic photos that explain everything for each area."

A small concrete pumphouse was built at the end of the 600-foot Treadwell Wharf to provide water for milling ore and for fire protection.

High up in the valley, Harmon stopped at the Sheep Creek camp Echo Bay had built. "That's the portal," he noted, pointing to where a gently sloping grassy track ended at a metal gate under a half-round Quonset roof. "The original entrance was all timbered," he explained. "The ore came out of the Perseverance by rail. We can go all the way through the mountain to the other side where the A-J and Gastineau started. The 13th level of the Perseverance came out the Sheep Creek portal. Because of avalanche problems, they moved the Gastineau to this side."

The road followed the old railway grade from the portal to the coarse crushing plant, now a skeleton of steel girders and bare concrete foundations set into the steep hillside. Here, an aerial tram brought supplies and workers up from the beach. The crushed rock dropped down two chutes inside the mountain and went on conveyors to the mill, located lower down by the parking lot and gift store.

Expertly negotiating the switchback road, Harmon arrived at the gaping mouth of the adit, where ore dropped down from the crusher.

"This is the prettiest portal I've ever worked in," Harmon stated. A waterfall splashed down fern-draped rocks and vegetation framed the rocky entrance. Donning hardhat and headlamp, he unlocked the metal entrance gate and flipped on electric lights. As he guided us into the mountain, he explained miners' terms for the "ribs," "back" and "face." Stopping at thick, white ribbons of quartz veins, he swept his headlamp over the wall. "This is typical of A-J quartz veins," he noted. "The surrounding rocks are 250 million years old. The quartz came in some 50 million years ago. All the gold is associated with quartz."

At a display of hand steel and jackleg drilling, Harmon explained the placement and timed blasting of holes needed to advance the work. "We run the jackleg drill," he said with a grin. "Visitors get earplugs because it gets pretty loud. We stay in here about 45 minutes. The rock temperature is always 36.5 degrees, so they're happy when the tour ends."

Outside the adit, a large boulder of quartz had shattered, pieces lying around it for visitors to take home as samples.

"This shut down because of World War I and never reopened," Harmon said. "It was the largest gold producer in the world at one point."

Under the leadership of Frederick Bradley, mining engineer and former president of the Bunker Hill and Sullivan Mine in Idaho, the A-J Mine, located near the Perseverance Mine above Silver Bow Basin, eventually combined all the big mines of the area. In 1917, Bradley had the Gold Creek Tunnel driven under the A-J ore body. From its mouth on the steep slope above Juneau, the tunnel fed ore into a multitiered mill. The original mill was designed to fine-grind the ore in pebble mills, similar to how Arizona copper ore was treated, but the Juneau rocks were much harder. After a redesign, the operation was a success, although the mine didn't make a profit until 1928.

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Gold Fakes and Frauds

Swindles and Scams throughout History

Story and Photos by Bob Jones

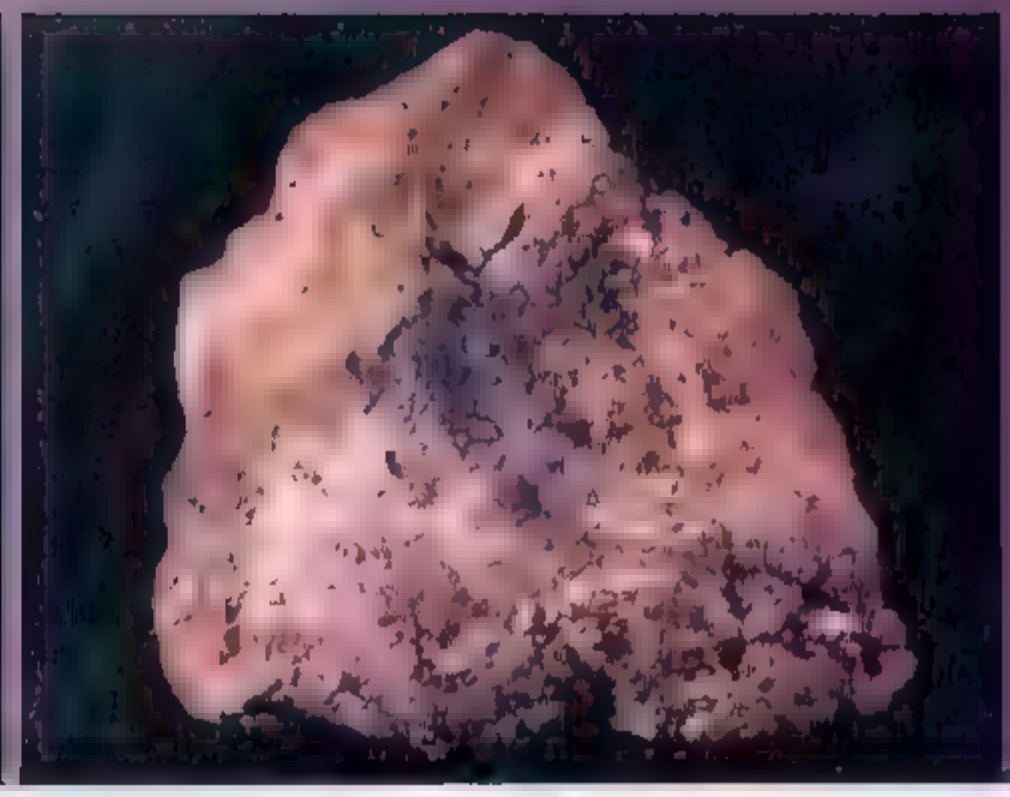
Everyone loves gold! Its lovely metallic yellow color, almost unique among the Earth's natural elements, is at once its greatest charisma and its greatest misrepresentation. Gold's color is so popular that, if you can't afford gold, you use something that looks like gold, such as the brass alloy of zinc and copper, which was developed around 500 B.C.

Gold is so precious and popular that it is not at all surprising that the mineral and mining literature is fraught with tales of people faking gold for financial gain. Real gold has also been used to defraud the unsuspecting. When the hunt for gold in the Western United States was at its height, no one knows how many gold and silver mines were sold on the basis of salted claims or falsely inflated values. How many gold or silver specimens have been sold that later proved to be faked in some way?

The largest faked gold specimen I've ever seen supposedly came from the famous American Tunnel Mine in Gladstone, an old mining camp next to Silverton, Colorado, in the San Juan Mountains. Standard Metals of Canada had obtained the gold mining rights to the Gold King Mine, a legitimate producer, but could not gain access to the property to commence mining. The company dug the American Tunnel in the 1950s simply as an access tunnel to reach the Gold King.

During tunneling, miners cut across several wide quartz veins that were vuggy enough that crystal cavities had formed. These were replete with fine

Archie Wilson created some wonderfully realistic models of Breckenridge, Colorado, gold that many people thought were real specimens.



Cripple Creek, Colorado, gold ore, when heated, produces a series of gold bubbles that makes the low-grade ore look quite rich.

specimens of quartz crystals, choice, small, pink rhodochrosite crystals, and simple cubes of colorless to pale green fluorite. Gold, however, was not one of the minerals encountered.

The specimen I was shown was an 8-inch mass of sulfide rock covered by snow-white quartz. The quartz had very fine, small, pink rhombohedrons of rhodochrosite scattered profusely over the surface. Lodged among these pink crystals, and contrasting strongly with the white quartz, was gold. The gold did not show any faces at all, nor was it crystallized. It was simply rounded, misshapen pieces resting on the quartz. The specimen in question had been bought at a rock shop in Silverton by a friend of mine. The new owner even had a certificate that attested to the authenticity of the gold. Luckily, that certificate had a return policy attached.

Now, the American Tunnel is a legitimate source for rhodochrosite, quartz and fluorite, but it was never a gold mine! The American Tunnel had not been dug in gold-bearing rock, so a gold-rich specimen of rhodochrosite purported to be from that tunnel was immediately suspect.

The specimen sure looked like it was rich with gold, but it was immediately obvious to me that none of the gold was actually in the quartz—it was just *on* the quartz. Gold enclosed in quartz is a sure sign that at least some of the gold is natural, as the later quartz formed around it. But the gold on this specimen was just sitting in the crevices and seams of the specimen. An X-ray of the gold seemed a logical way to resolve the doubts I had.

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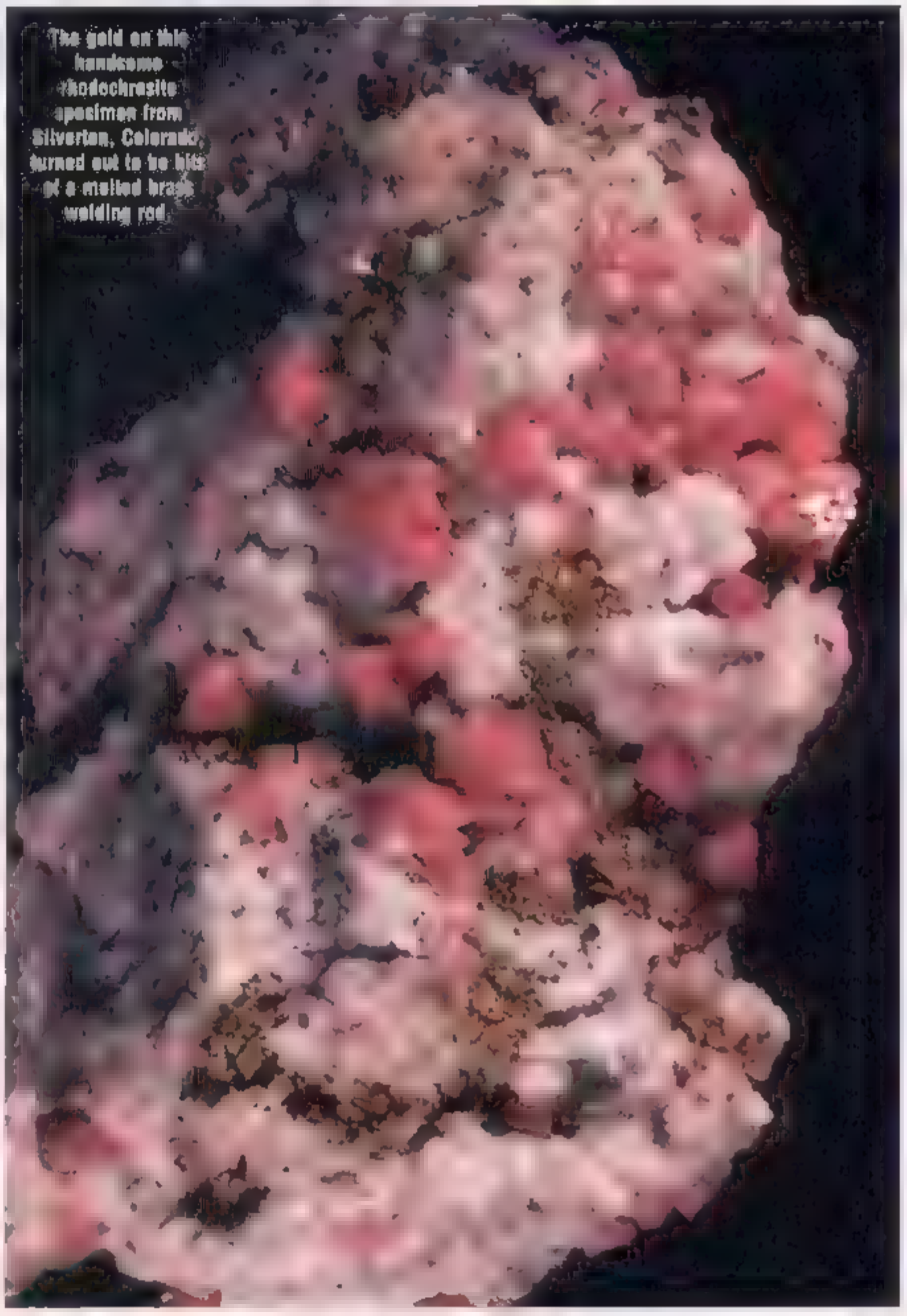

Gold Fakes and Frauds *from page 29*

Sure enough, the X-ray showed there was no gold on the specimen at all, only lovely bright golden brass! In fact, chemical analysis of the brass showed that someone had melted a brass welding rod and allowed the molten metal to drip onto the specimen. Lucky, the owner was able to get his money back. I have often wondered where that specimen turned up next!

While any experienced collector could immediately suspect such a specimen, plenty of specimens are not so obvious. In the 1980s, I finally met a fellow I had heard a lot about in connection with the artistic creation of gold fakes. His name was Archie Wilson, and he is long since dead, but was quite an interesting character when alive. Archie used to sell specimens that could easily be mistaken for real gold. He insisted to me that his creations were models of famous gold specimens, so were legitimate. Of course, he had already had his run-ins with the law and had served time for gold fraud, apparently because he sold his "good models" as the real thing.

Archie was very skilled at making models of the leafy hacked gold that had come from the mines around Breckenridge, Colorado, in the late 1800s. These natural specimens consisted of broad, thin, irregularly shaped septa of gold whose surfaces were covered with microcrystals of gold, and gold trigons and gold wires in tangles. One mine yielded so much wire gold it was called the Wire Patch Mine. The finest examples of these natural golds from Breckenridge are in the Denver Museum of Science and Nature.

To replicate these handsome specimens, Archie would make a model, probably out of papier mache or something similar. Then he covered the model with real 22 karat gold leaf, close to pure gold. This gave the models the same color and luster as real gold. Obviously, these fakes had little weight compared to real gold. Archie would fasten the model to a wooden base that looked like a solid block of wood. Then he encased the gold in glass, which was sealed to the wooden base. This prevented anyone from handling the gold directly. The wooden base was actually hollow inside, and a slab of something like lead was stashed inside. That gave the entire model the necessary weight to simulate that of gold.

Sold as models, they were very pretty shelf decorations. The problem was that, once the piece had changed hands a time or two, the "model" designation was easily lost and the new owner thought the specimen was natural gold.

In the early 1980s, I contacted Archie and he came by my place with about 20 of his creations. We had a long talk about them, and he was kind enough to let me photograph them out of their glass containers. He set them in front of the camera, I pushed the button, and he put the specimen back in its container, so I really didn't get to handle the pieces. When he left, he gave me a small metal box containing a looping piece of wire gold, another of his creations.

A couple of years after Archie died, and I had forgotten about him, I got a phone call from someone who identified himself as a banker in California. Someone had given him my phone number because the banker was trying to find out about Arenie's gold specimens. I asked why he was inquiring, and he said that his bank had made a huge loan to someone using Arenie's golds as collateral. If memory serves me, the loan was in six figures! When I explained what I knew about Arenie's creations, there was silence on the other end of the line. Finally, a quaking voice said "Thank you" and he hung up! Who says crime doesn't pay?

Of course, gold fakes and frauds are nothing new. You are all familiar with the story of the Greek scientist Archimedes of Syracuse. The local king had commissioned a gold crown, but after it was made, someone whispered in the king's ear that the goldsmith who made the crown had adulterated it with silver and pocketed the golden difference. Archimedes was chosen to determine whether the crown was pure gold. He could not melt or damage the crown to determine its composition. What to do?

As the story goes, as Archimedes was about to take a bath, the water his body displaced when he got into the tub suggested an experiment to determine the crown's composition. He was so excited he grabbed a towel and ran down the street yelling "Eureka!" He tested the crown and proved that it had been adulterated. Needless to say, the goldsmith who made the crown suddenly suffered poor health! Today, we use this specific gravity (SG) test to help identify substances, including minerals.

So adulterating gold is nothing new. In fact, we do it legally all the time. Pure gold is too soft to use in jewelry. In order to harden it, we purposely adulterate it, usually with silver, but also with copper or other metal. This also achieves slight variations in gold's color. This alloying is reflected in the karat weight of the gold (i.e. 14 karat, 22 karat, etc.). Sometimes, we even make alloys to improve the yellow color

Over 1,000 years ago, alchemists were perpetrating gold fraud, claiming to produce gold from lead. The gold was added to the mix by sleight of hand

Jewelry made with 10 or 14 karat gold is still yellow, but not as rich as 24-karat gold. This gold alloy jewelry is "flashed" with a thin 22-karat gold plating to enrich the color.

Over 1,000 years ago, alchemists claimed to produce gold from lead. The fraud was performed right in front of the customer using sleight of hand. Muttering mumbo-jumbo, the alchemist would create a molten mixture of sulfur, lead, and an assortment of exotic ingredients. Then the alchemist might stir the mix with his metal rod until the right moment of suspense had been reached. The effort always produced a small button of gold, much to the amazement of the onlookers. The alchemist's trick was to introduce real gold into the mix during the demonstration, either while the onlooker was distracted or through a hollow stirring rod.

It is not unusual for charlatans to cast "natural" gold crystals and nuggets. A suspected cast can be examined for marks left by the casting process. There might be evidence of sprues, mold seams, filing marks, and the like, but only if the caster has been exceedingly careless, and that's not likely. The best test is to assay the suspected gold, as those intent on defrauding seldom use pure gold in their creations.

A few years ago, a number of single gold crystals reportedly from Venezuela were being offered for sale at major shows. Almost immediately, a controversy arose as to whether the crystals were natural or had been cast. If cast, they were so good that no one could prove otherwise, so the controversy was never settled.

More recently, some wonderfully aesthetic silver specimens came into this country from Central Europe. Again, a controversy burst forth. One rumor had it that they had been part of a museum collection whose surplus was being sold. Others said they were from an old silver mine, a lucky find by an amateur digger. The controversy raged in the Letters to the Editor section of a popular national mineralogy magazine and in e-mails to Europe and back, but the question was never satisfactorily answered as far as I know.

Another example of gold fakes happened in Tucson some years ago. A Canadian dealer, long since dead, showed up in Tucson selling wonderful gold-plated arborescent coppers for $1 each! Since copper and gold crystals form similarly, black and-white photographs of nice arborescent specimens of copper and gold would look exactly alike. Though our Canadian dealer was honestly identifying his gold-plated coppers, imagine how easy it would be to offer one of them for sale as the real thing!

There's yet another way that gold can be used fraudulently. One day, a local bank invited me to appraise a native gold collection that it had taken as collateral for a loan. The owner of the gold had defaulted and the collection was going to be put up for sale, so I appraised and photographed the gold specimens, which were all natural.

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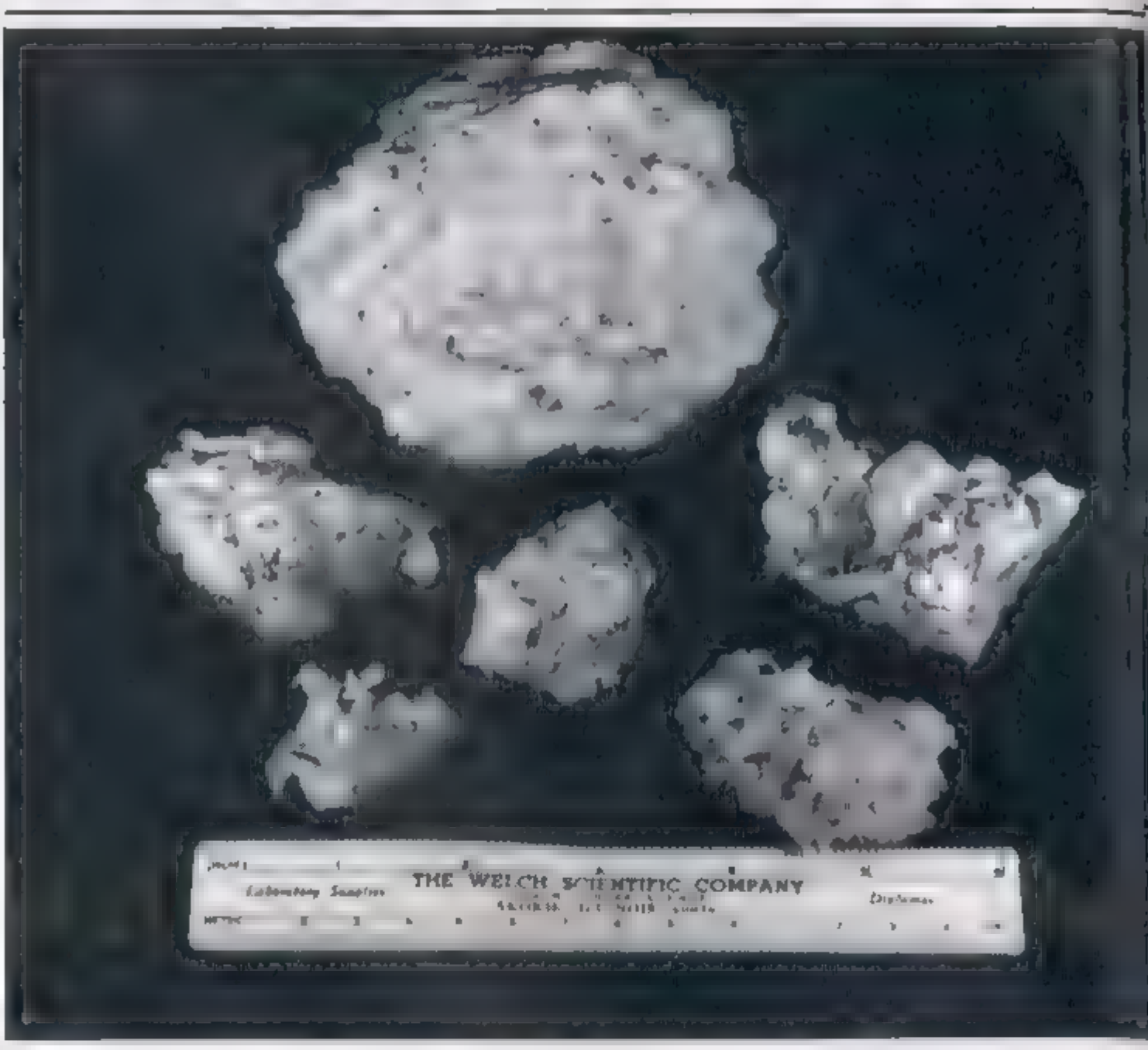
Gold Fakes and Frauds *from page 31*



These specimens of real gold were borrowed from friends by a fellow who used them to get a large bank loan and then disappeared.

Sometime later, I used one of the gold photos to illustrate an article in *Rock & Gem* magazine. A friend of mine contacted me and asked about the gold, he was sure he was the owner and wondered where I got the picture. I dug out my shots of the gold collection, and he identified several pieces that were his.

It seems that a friend of the guy who actually owned the gold had borrowed the pieces and had also borrowed others from friends to put together the gold collection now in possession of the bank. The fellow had gotten his loan and dropped out of sight, leaving the bank with the golds that belonged to his friends. So you do not think this is [illegible] occurrence, I've seen miner[illegible]mens "borrowed" and [illegible]old instead of being returned [illegible]ss, even in rockhounding, it t[illegible]ail kinds.

When prospectors began to open the American West and discovered gold and silver deposits, fraud was not far behind. The funniest attempt to commit mining fraud probably happened in the Comstock Lode area, which started out as a gold camp, but ended up one of America's richest silver strikes. The fraud happened when the owners of the North Ophir Mine, a hole in the ground almost bereft of silver values, decided they had to sell. In the Bible, Ophir was land of great gold wealth. So the name Opair is often used to dramatically improve sale prospects and perhaps encourage a better price.

The North Ophir owners salted their mine tunnels with pure silver, obtained by melting down U.S. silver dollars and appropriately blackened to look natural. They jammed small bits of the silver into every seam and crack of the mine tunnel face so it would be seen when a prospective buyer did an inspection. It would also improve any assay work done on collected samples.

Now, salting a property was a time-honored practice in the West, and often led to some raucous celebrations when successful. Anyone buying a mine was fair game, especially if the mining camp was on the downside, with the local mines running into borrasca. Sometimes, the mine owners would get unsolicited help from local miners, who would salt a vein to ensure a sale and guarantee a continuation of work.

The prospective buyers of the North

Ophir took samples and a sale seemed imminent. Then one of the buyers checked the ore samples more closely, and on one of the bits of "natural" silver they had gathered in the mine, he detected the words "-ted States of." The jig was up, for the mine owners had been careless in their melting of coins. Needless to say, the deal fell through.

It is not unusual for charlatans to cast "natural" gold crystals and nuggets. A suspected cast can be examined for marks left by the casting process.

During the gold rush days of America, salting techniques were pretty crude but gradually very skillful techniques were developed and were often successful. In more than one case, when someone was trying to sell a claim along a stream, flakes of gold were put in the creek bottom, where the buyer might test for color. If a buyer was using a rocker to check the gravels, the owner might load his pipe with gold dust instead of tobacco and accidentally knock his ashes into the rocker. Any distraction during the testing of property gave the owners a chance to sweeten the ground, so buyers and hired consultants checking the property had to really be alert to any suspicious event or behavior.

Sometimes, the charlatan didn't have to introduce illicit gold directly into the property. For example, the gold ore in Cripple Creek, Colorado, occurs in chemical combination with tellurium in the form of calaverite. Calaverite is a silvery mineral that is often found sparsely scattered in the local rock. Such a rock often did not carry enough gold to make a property pay, but intense heat would boil off the tellurium, leaving behind a small, but bright, series of bubbles of nearly pure gold. Enough of these bubbles would thrill a prospective buyer into making an immediate purchase.

One of the ways of salting an underground mine was to load a shotgun with gold dust and blast the face of the mine tunnel. The gold would embed itself in the rock, so any sample collected would be tainted. Smart prospective buyers would insist on blasting away the face to get to fresh ground, but that didn't stop the owner's efforts to salt the digs. Sometimes, the mine owner could introduce gold dust into the blast holes along with the dynamite. When the blast occurred, the tenor of the ore would show improvement.

One of the more insidious ways of salting a property happened after samples were collected and bagged and ready to go to the assayer. Sampling was often done by an expert hired by the prospective buyer. These experts were wise to all the fraud techniques, so they were not easy to fool, but it was done again and again.

A standard patent medicine in use at this time was purported to treat kidney ailments. The treatment was gold chloride, a liquid that was consumed, but the only cure it really offered was a cure for low-grade ore. All the owner had to do was drink the gold chloride sometime before the sampling process, then urinate on the sample bags before they made it to the assay office!

A second useful liquid was silver nitrate. It could be poured over samples either in or out of a sample bag to enrich the yield at the assay office.

Fortunately for miners, engineers, and prospective buyers, assayers as a lot were painfully honest and highly respected. Sure, there was the occasional rotten apple in the barrel, but by and large, assayers were looked upon as the equivalent of the local preacher. My son Bill, for example, is a registered assayer in Colorado, and more than once he has been offered good deals to extract the yellow metal from rich samples highgraded from a mine. In every case, he turned down the miners cold, thus maintaining a standard that goes back a century and more.

Archie Wilson may no longer be with us, but the old saying "caveat emptor" (buyer beware) is just as valid in mineral collecting today as it was back in Wild West mining days. We may not have as many mining deals fraught with shady doings, but the temptation to improve a specimen where improvement is fraudulent is still with us. The advice often given to gem and jewelry buyers is also valid for collectors: Do business with mineral dealers you know and trust.

GOLD AND GEM HIGHWAYS

ROADSIDE PANNING SITES IN CALIFORNIA

Part X: Find Gold in Sutter, Trinity, Tulare, Tuolumne, and Yuba

Story and Maps
by David and Clois Walker

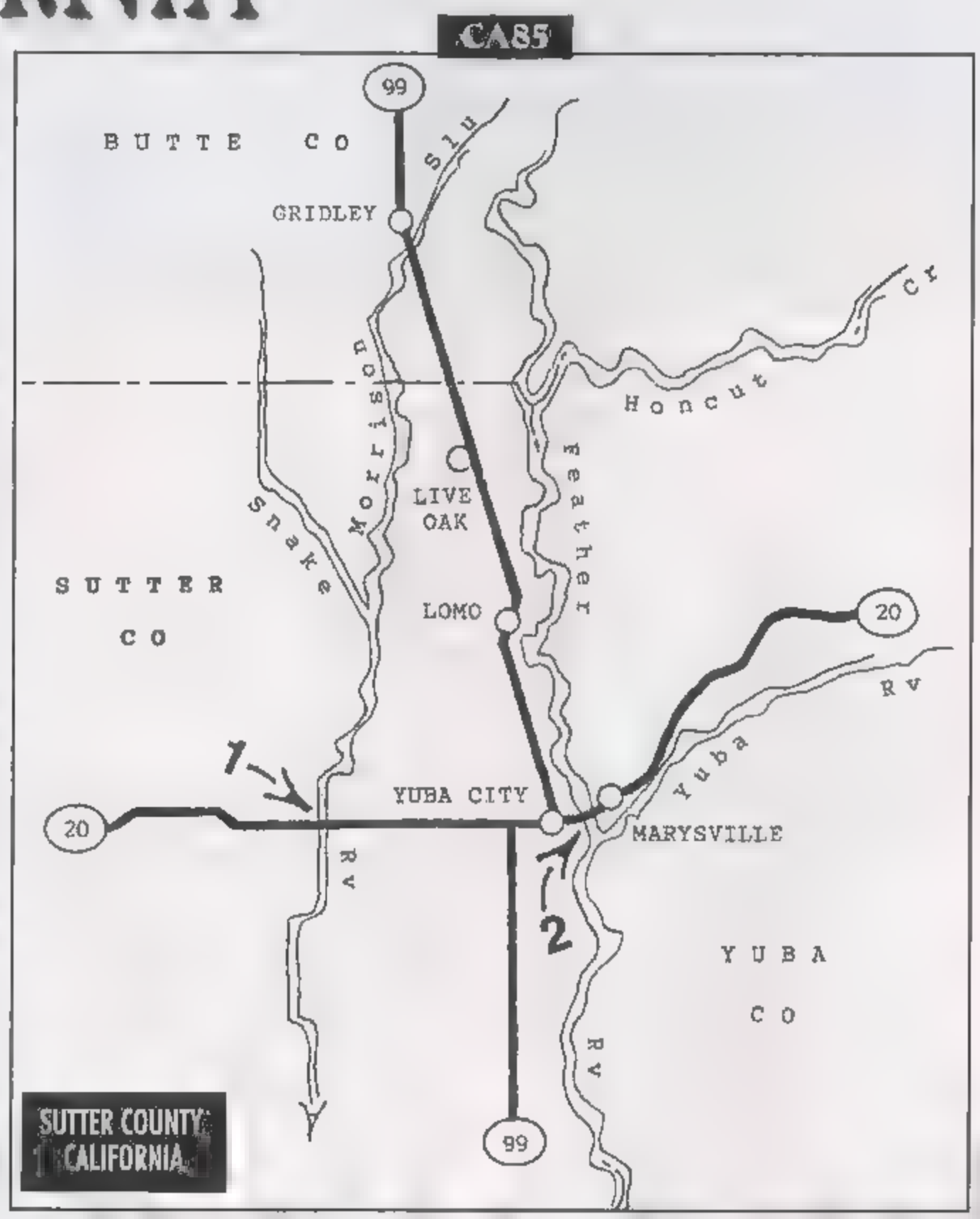
This is the 10th in a series of 10 articles containing county-by-county maps of suggested panning and screening sites at highway/stream crossings where appreciable finds have been previously reported on upstream watersheds. The principles of erosion make it likely that minerals and gemstones have been deposited in river gravels, awaiting removal by a rockhound with a pan.

The idea behind this study is that the locations will be easy to reach, without tramping over hill and dale. It also assumes that the highway crossings are government property and there will be no need to locate and get permission from property owners. However, readers run the risk of prosecution if they cross onto private land, however inadvertently. To find out where highway rights of way begin and end, contact Barry Cowen at the Right of Way Division of the California Department of Transportation (Caltrans) at (916) 654-5075 *before* you visit these sites.

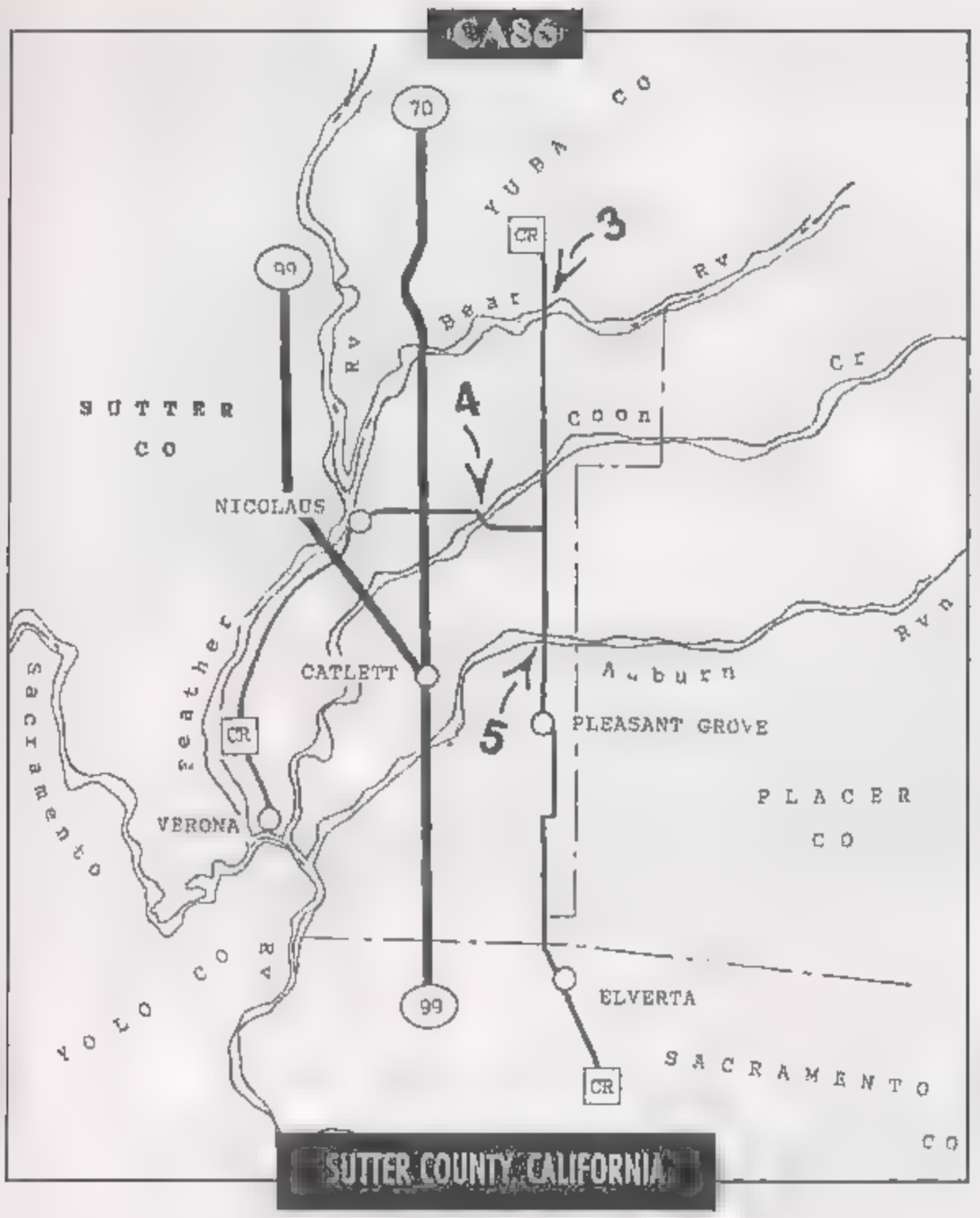
Remember, too, that the government to which these rights of way belong has some regulations of its own. Be sure to observe the usual safety and environmental standards if you want to collect without a hassle.

The maps provided contain the most up-to-date information available to us, but it is advisable to consult a current state highway map when planning an outing, for overall orientation in the field and because highway designations have been known to change.

So good luck! While we can't guarantee you'll hit the jackpot, we can almost assure an enjoyable outing.



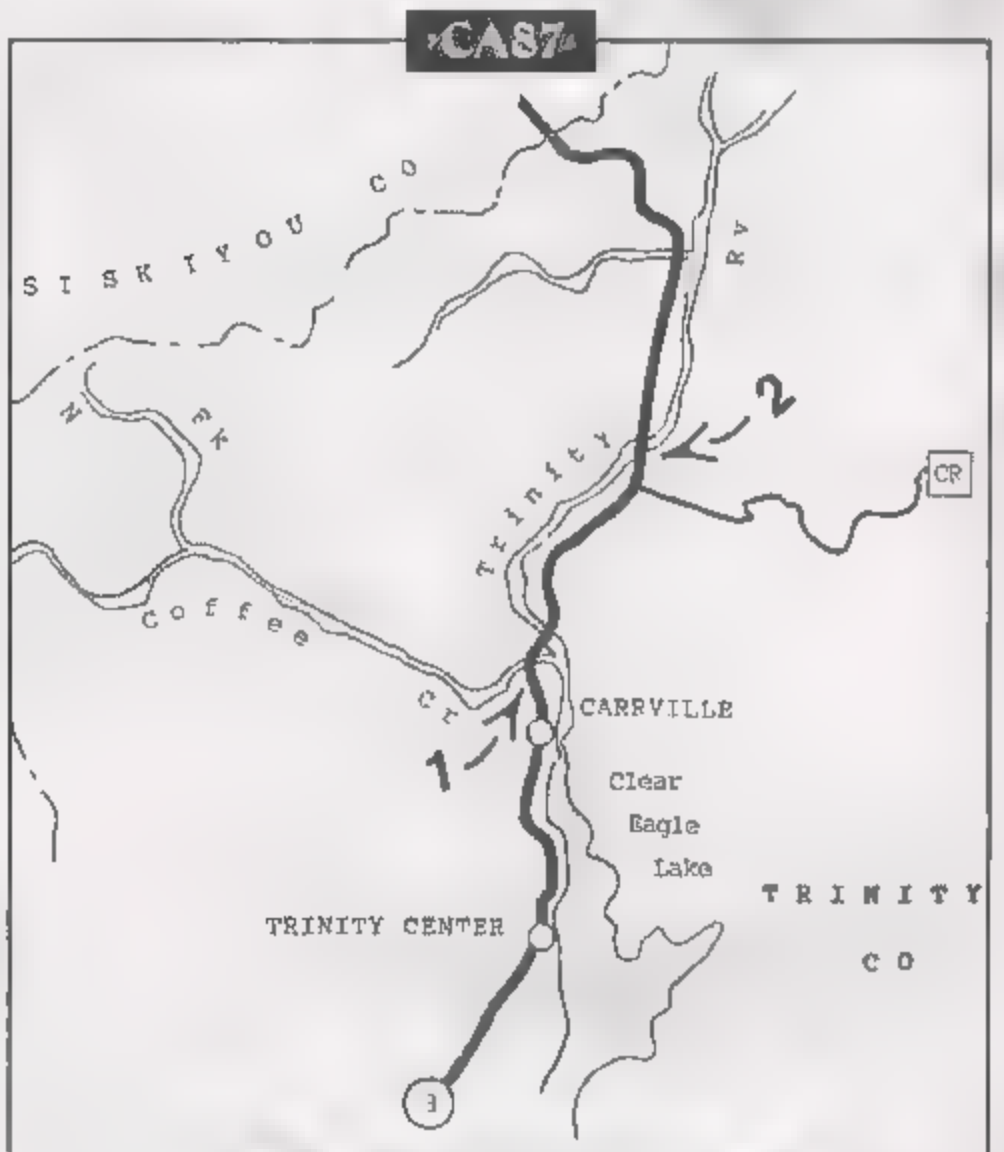
SUTTER COUNTY (Maps CA85-86)
SITE 1 **Snake River/state Route 20** crossing near **Yuba City.**
Vicinity finds indicate gold potential
SITE 2 **Feather River/state Route 20** crossing, near **Yuba City.**
Vicinity finds indicate gold potential



SITE 3 **Bear River/County Road** crossing, near **Nicolaus.** Vicinity finds indicate gold potential

SITE 4 **Coon Creek/County Road** crossing, near **Nicolaus.** Vicinity finds indicate gold potential.

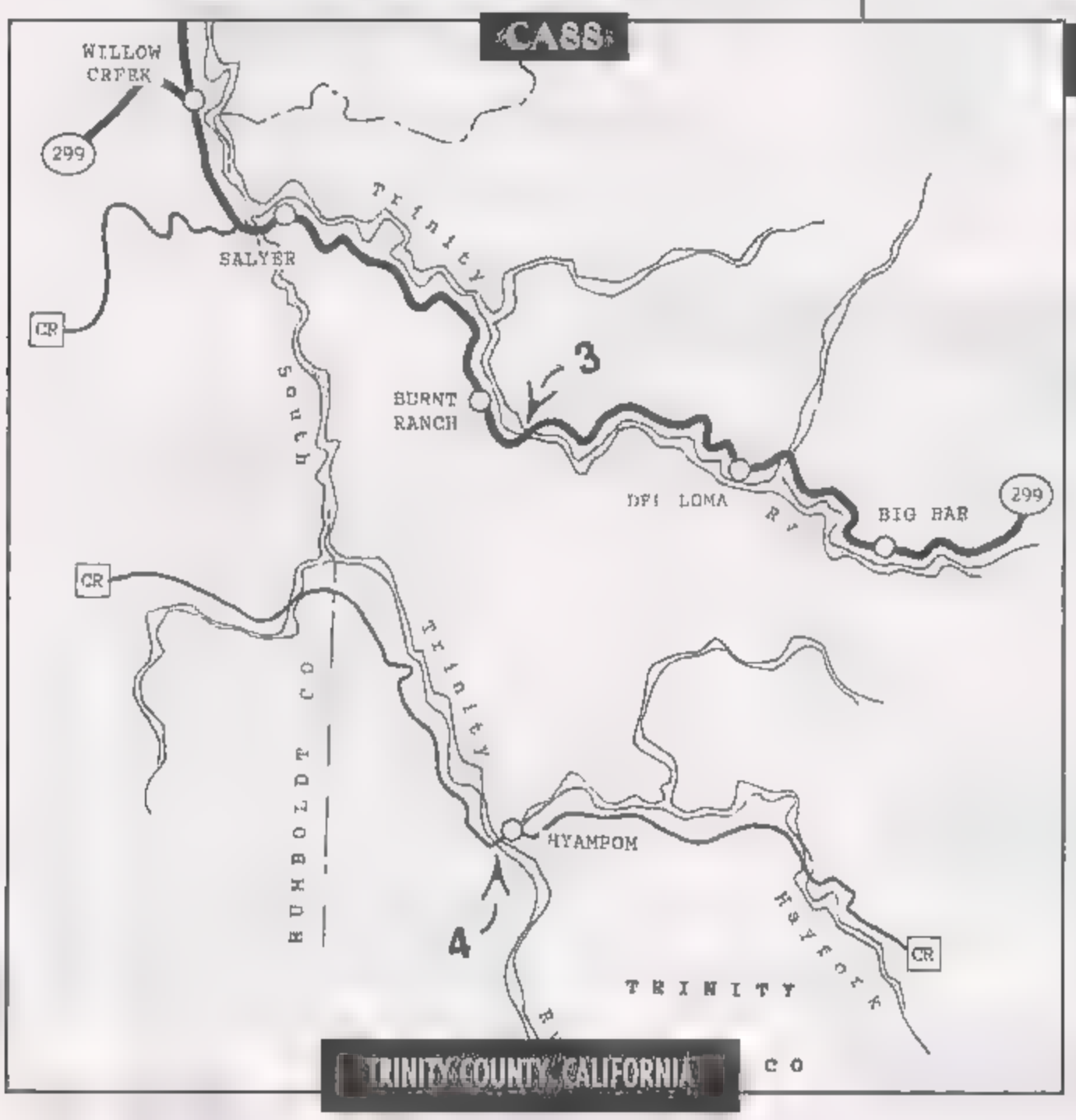
SITE 5 **Auburn River/County Road** crossing, near **Pleasant Grove.** Vicinity finds indicate gold potential



TRINITY COUNTY (Maps CA87-90)

SITE 1 **Coffee Creek/state Route 3** crossing, near **Carrville.** Vicinity finds include chalcedony, gold, jasper, platinum, and silicified wood.

SITE 2. **Trinity River/state Route 3** crossing, near **Carrville.** Vicinity finds indicate gold potential



SITE 3 **Trinity River/state Route 299** crossing near **Burnt Ranch.** Vicinity finds include chalcedony, gold, jade, jasper, platinum, and silicified wood.

SITE 4 **South Fork Trinity River/ County Road** crossing, near **Hyampom.** Vicinity finds indicate gold potential

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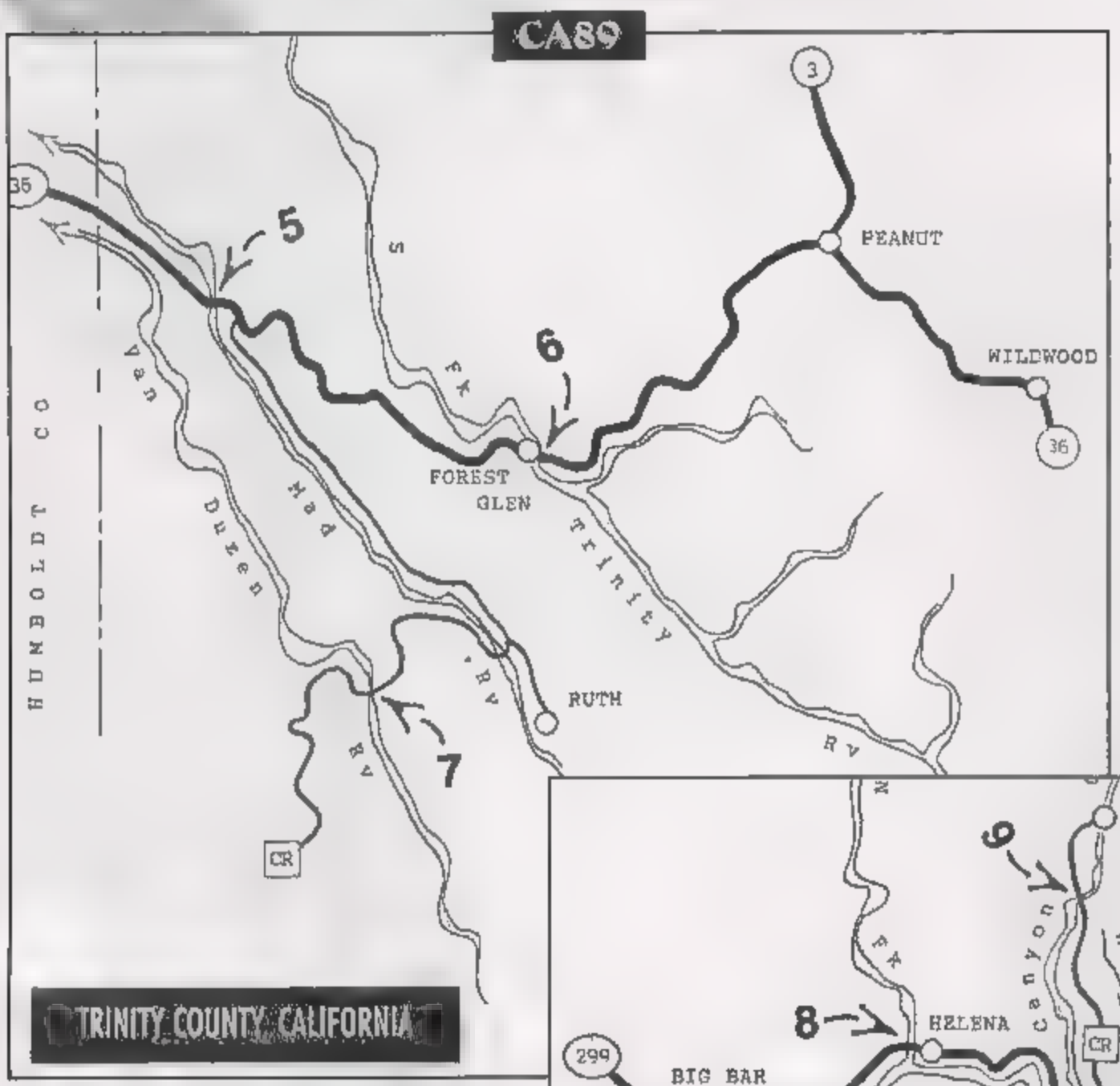
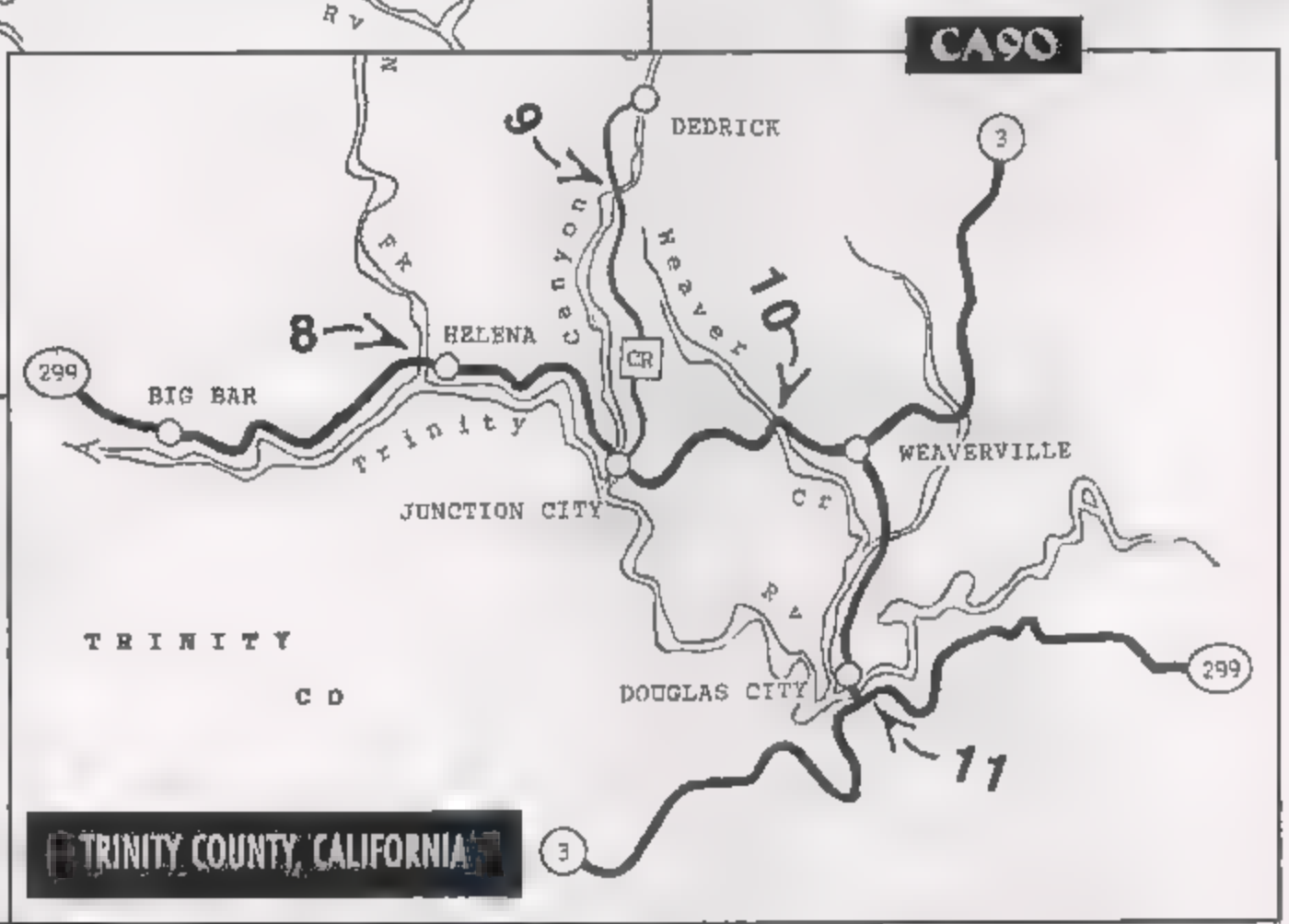
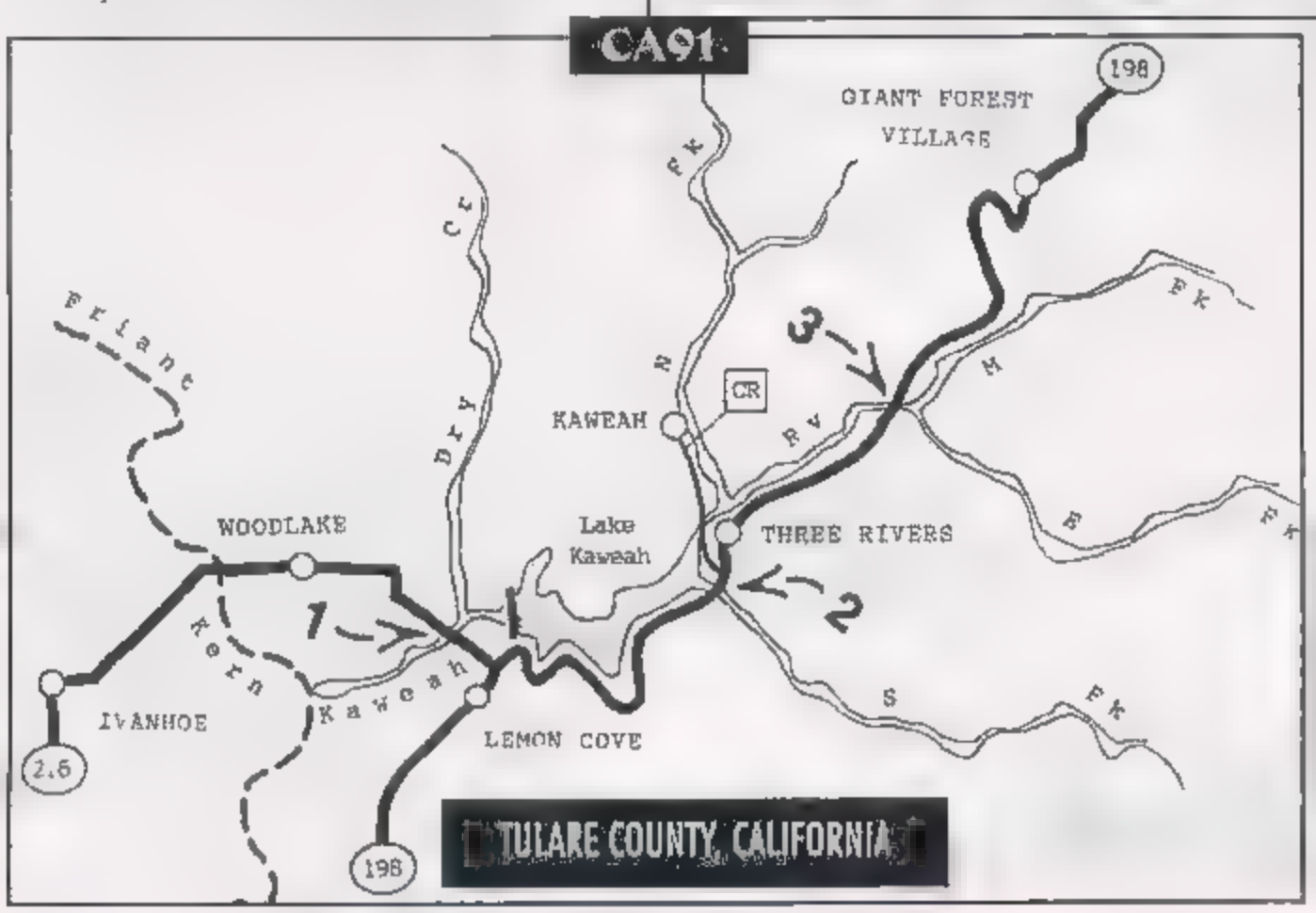


SITE 5. **Mad River/state Route 36** crossing, near **Forest Glen.** Vicinity finds include agate and jasper
SITE 6. **South Fork Trinity River/state Route 36** crossing, near **Forest Glen.** Vicinity finds indicate gold potential
SITE 7. **Van Duzen River/County Road** crossing, near **Ruth.** Vicinity finds include agate, gold, jade, and jasper



SITE 8. **North Fork Trinity River/state Route 299** crossing, near **Helena.** Vicinity finds include gold and rhodonite.
SITE 9. **Canyon Creek/County Road** crossing, near **Junction City.** Vicinity finds include gold and rhodonite.
SITE 10. **Weaver Creek/state Route 299** crossing, near **Weaverville.** Vicinity finds include epidote, garnet, gold, and zircon
SITE 11. **Tributary Trinity River/state Route 299** crossing, near **Douglas City.** Vicinity finds include chalcedony, gold, platinum, and silicified wood



TULARE COUNTY (Maps CA91-92)
SITE 1. **Kaweah River/state Route 216** crossing, near **Woodlake.** Vicinity finds include epidote and rhodonite
SITE 2. **South Fork Kaweah River/state Route 198** crossing, near **Three Rivers.** Vicinity finds include epidote and rhodonite
SITE 3. **Kaweah River/state Route 198** crossing, near **Three Rivers.** Vicinity finds include epidote and rhodonite.

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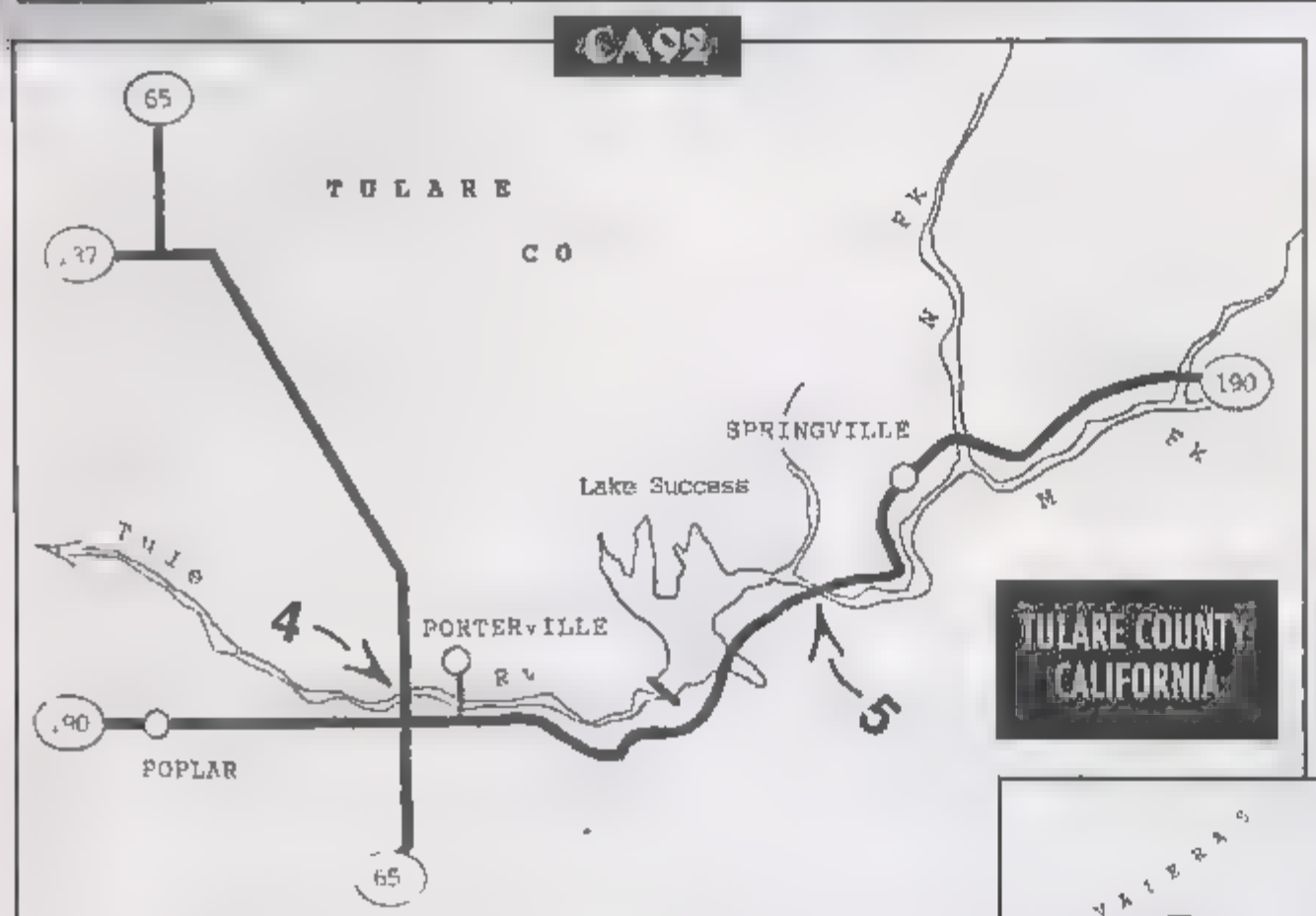
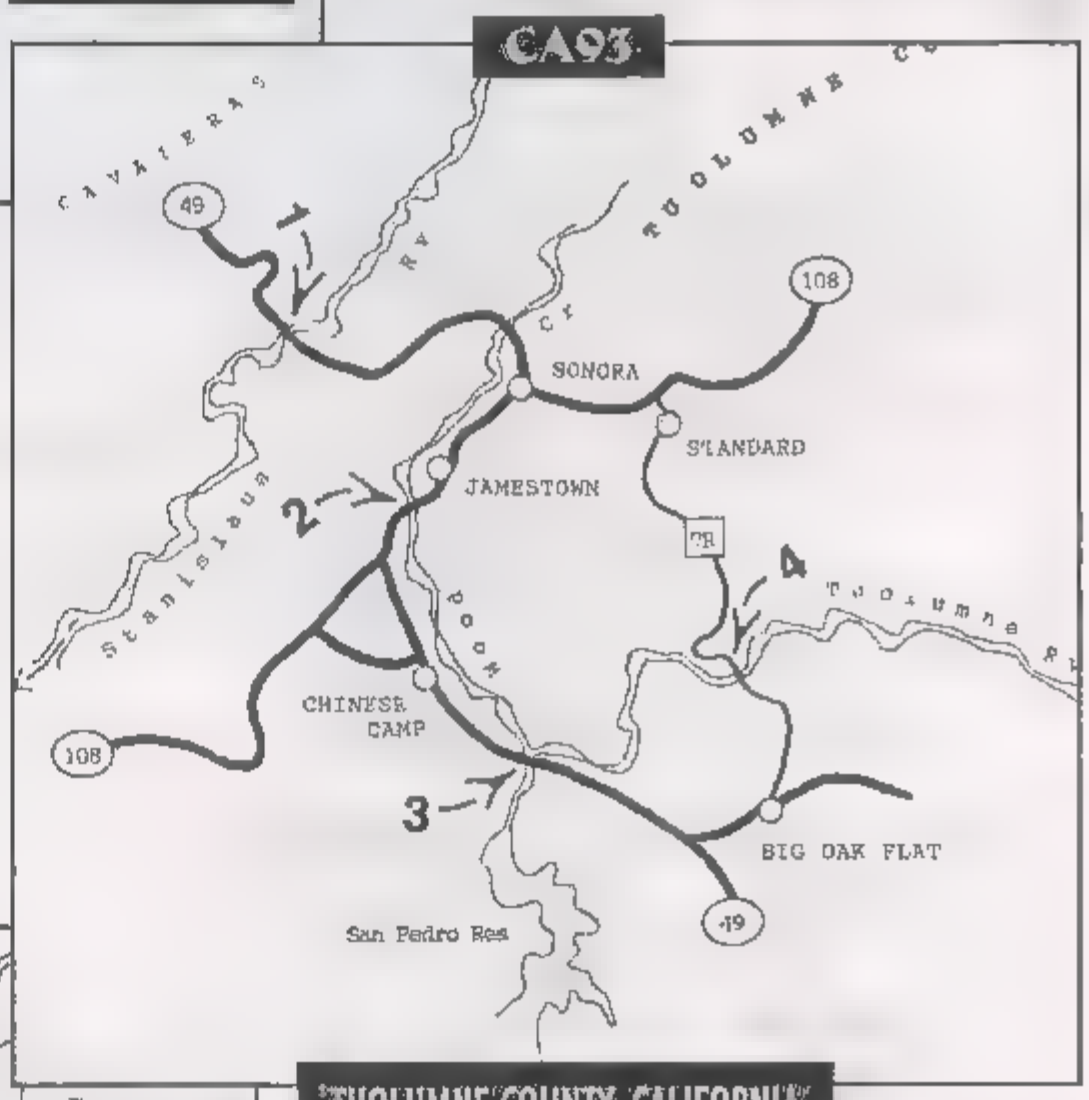


SITE 4 **Tule River/state Route 137** crossing, near **Poplar.** Vicinity finds include chalcedony, jade and opal

SITE 5 **Tule River/state Route 190** crossing, near **Springville.** Vicinity finds include chalcedony, opal and rhodonite.



TUOLUMNE COUNTY (Map CA93)

SITE 1 **Stanislaus River/state Route 49** crossing, near **Sonora.** Vicinity finds indicate gold potential

SITE 2 **Wood Creek/state Route 108** crossing, near **Jamestown.** Vicinity finds include garnet and gold

SITE 3 **Wood Creek/state Route 49** crossing, near **Chinese Camp.** Vicinity finds include garnet and gold

SITE 4 **Tuolumne River/County Road** crossing near **Big Oak Flat.** Vicinity finds include garnet and gold

YUBA COUNTY (Map CA94)

SITE 1 **Yuba River/state Route 70** crossing near **Marysville.** Vicinity finds indicate gold potential

SITE 2 **Dry Creek/state Route 20** crossing near **Smartville** Vicinity finds indicate gold potential

SITE 3 **Yuba River/state Route 20** crossing near **Smartville.** Vicinity finds indicate gold potential

The official state highway map is suggested in conjunction with these maps for overall orientation in the field.

THE FRUGAL COLLECTOR

PHOSPHATE MINERALS

PART II:

They're Colorful and Collectible

Story by Bob Jones

In Part I of this story, I described the lovely green variscite lapidary material from Fairfield and elsewhere in Utah. A hydrous aluminum phosphate, variscite has a companion phosphate, turquoise. They do not form a series, but green turquoise and variscite are easily confused. Fortunately, turquoise, a hydrous hydrate copper aluminum phosphate, is most often a shade of blue. It has been called the sky-blue stone by Native Americans, an indication of their reverence for this lovely gem. Turquoise has been revered by many other cultures, including the Egyptians, Persians, Chinese, and Aztecs. The stone is pretty, easy to work, and available in some quantity if the culture is near copper deposits.

Because of its gorgeous color and workability, turquoise was the first gemstone worked by humans. Most texts suggest turquoise was first worked about 5,500 years ago, while lapis came onto the scene 2,000 years later. In the eyes of the lapidary, turquoise has been, and still is, the most popular and best known of all the phosphates. It was worked by early cultures into beads, used in inlay, and even carved, uses we still enjoy today.

The earliest sources of turquoise were in Persia, now Iran, and on the Sinai Peninsula. The Persian turquoise, mined in the Ali-Mirsa-Kuh Mountains of Nishapur, Iran, has long been considered the standard of turquoise blue. Its intense color and contrasting spider web patterns add to its appeal and variety. Little or no turquoise comes from the centuries-old Iranian deposits today.

BOB JONES PHOTO

This choice vivianite specimen from Lemhi County, Idaho, has crystals over 4 inches long.

The turquoise on the Sinai Peninsula was worked furiously by the slaves of the ancient Egyptians. Most of it came from Wadi Maghara. Long caravans would wind their way into the barren desert to mine both turquoise and malachite from the rock formations there. These digs were re-discovered some decades ago, and small amounts of malachite and turquoise were found, along with the remains of the living quarters for slaves and guards and shrines to the gods. Again, nothing comes from these ancient digs now.

The first important modern compilation of data and information including color photos of turquoise was written by Joseph Pogue in 1915. It covers the long history and use of this blue stone. Of particular interest, much of the text is devoted to the history and evolution of the use of turquoise by Native Americans, highlighting the immense amounts of worked turquoise discovered in the ruins in Chaco Canyon, New Mexico. Tens of thousands of small beads, carvings, and other worked turquoise were unearthed

BOB JONES PHOTO

Phospyllite, this one from Bolivia, is a rare phosphate mineral

BOB JONES PHOTO

The mineral species ludlamite is closely related to vivianite Mexican specimens are among the best available today.

there by archeological digs. The turquoise was shown to have come from a variety of sources, mostly New Mexico, Arizona, and Colorado. Remarkably useful trade routes radiated out for hundreds of miles in all directions from this ancient cultural site. The Pouga book may still be obtained from antique and rare book dealers.

Three countries, Mexico, China, and the United States, currently produce turquoise in quantity, keeping the gem market viable. The primary U.S. sources are in Nevada and Arizona, with small quantities coming from New Mexico and Colorado. The Colorado turquoise comes from Cripple Creek, much better known for its massive gold production a hundred years ago. A very small number of these turquoise pieces show a trace of included native gold.

In most cases, turquoise is obtained from copper deposits as a byproduct. It tends to form best around the perimeter of copper porphyry deposits. When apatite in the rock breaks down, the phosphate radical is released and joins the aluminum from feldspar, the hydroxyl radical, and water to form turquoise. This is true of the copper porphyry deposits of Mexico and Arizona, particularly the now-closed Lavender Pit at Bisbee, Arizona, the Sleeping Beauty pit in the Miami-Globe area, which still produces, and several smaller pits west of Miami. Cananea, Mexico, has been a good source of large nuggets, as well.

The turquoise mines of Nevada, a very prolific source, are not blessed with large copper deposits. Copper was never present in sufficient quantity to mine there. The host rock was often a trychitic or similar rock of volcanic origin. Keep in mind that native copper is often found in small amounts in volcanic regions. So the turquoise developed here was, once again, the result of the breakdown of primary phosphates, which joined any available copper to form turquoise and, in some cases, chalcosiderite.

Chalcosiderite is nowhere near as common as turquoise, but it does form a series with turquoise as iron substitutes for copper in varying degrees. It usually occurs as small greenish spots in a darker matrix.

All these sources, as prolific as they have been, yield nuggets, masses, and seam fillings of turquoise. Fairly large masses will form where seams intersect. Some of these nuggets weigh tens of pounds, most of them were found in the early days of turquoise mining. Today, most turquoise ranges from fragments weighing a few ounces to only a few pounds.

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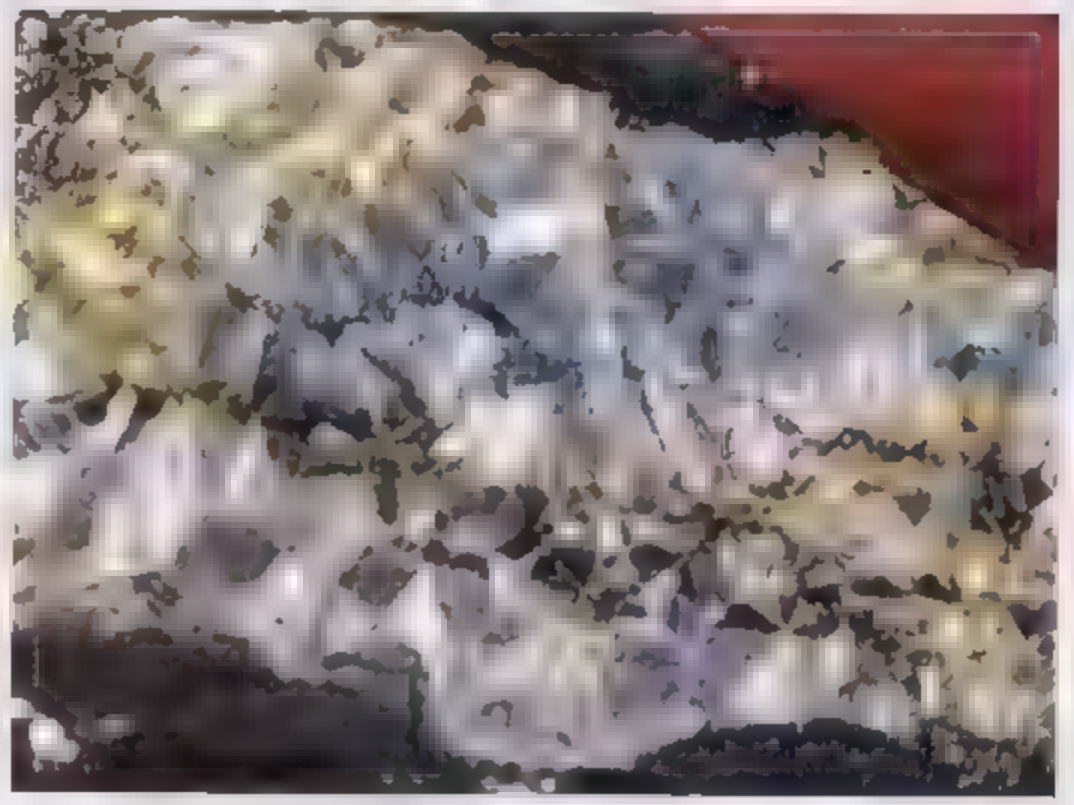


JEFF KURTZEMAN PHOTO

Some of the historically important silver mines in Germany also produced fine wavellite.

BOB JONES PHOTO

Idaho's Blackbird Mine yielded fine, small ludlamite crystals

Phosphate Minerals *from page 41*

As universal as massive turquoise is, there is only one source of true natural crystals. They are microcrystals to be sure but crystals nonetheless. They have been found at the only known source for turquoise in true microcrystals. The crystal deposit is a nondescript copper prospect near Lynch Station, Virginia, that was worked briefly by sinking a small incline shaft. It never produced a pound of metal, even when the miner smelted all the crystal-lined seams he could dig. Fortunately, he threw aside the rock fragments that only had a trace of blue on them. Thus, the waste dump rock was well laced with streaks and clusters of microcrystals of sky-blue turquoise. Plenty of collections, particularly those in the Middle Atlantic states, boast small rock fragments with a coating or smear of these rare blue crystals.

The deposit was a favored place for local collectors. It never produced show stoppers, but diligent dump digging always proved fruitful. Unfortunately, some years ago one avaricious collector decided to extract not the scattering of turquoise specimens on the dump, but the dump itself. Using heavy equipment, this greedy collector hauled off what had been a nice collecting site. As I recall, the person had first visited the place as a member of a local rock club. Several years later, I happened to visit that dump digger, who proudly showed me hundreds of crystallized turquoise specimens, piled in a drawer, that had been retrieved from that dump haul. I was more than a little disgusted!

Today, the copper mines of China are producing nice turquoise nuggets. Much of the Chinese turquoise has to be stabilized, as it is a bit soft and usually seamed with a soft black matrix. Still, sections of these nuggets are hard enough for cutting and polishing. I've sandblasted plenty of the Chinese specimens to clean them up for use, and they show fine color and take a good polish.

While most lapidary artists would love to work natural turquoise, as opposed to stabilized material, sound and suitably hard natural turquoise is virtually nonexistent, since most mines have long since given up their best. Few if any, copper deposits still retain even a vestige of their upper weathered oxide zones, in which turquoise forms best. Still, there are huge quantities of soft material that range in color from white to good blue. The material is porous and can be stabilized for a variety of uses.

The modern process of stabilizing turquoise has been around for over 50 years. In point of fact, turquoise has been stabilized or enhanced for centuries. Turquoise is porous enough to absorb

skin oils through prolonged contact and any greasy or oily substances, like animal fat. Any absorption tends to darken the color slightly and give the turquoise a bit of a luster. Native Americans used bear fat for these purposes.

There was never any pressing need for a stabilizing or enhancing technique for turquoise until the 1970s, though it had been in practice for a few decades. In 1972, major department stores including May Co., Saks Fifth Avenue, and Marshall Field advertised Native American jewelry as part of their holiday season promotion. The next year, the *Wall Street Journal* mentioned turquoise as a good investment. With that, natural turquoise nuggets, Native American jewelry, and turquoise carvings skyrocketed in value and sales, and the rush was on to supply the market. Old mines were reopened, a few new deposits were worked, stabilizing plants were started up or enlarged dramatically, and the creation of cheap substitutes like dyed howlite took off. The general public knew nothing about turquoise and fell victim to scam artists again and again. In the long term, this had a quenching effect on the market and turquoise, for a time, was a dirty word in the jewelry business.

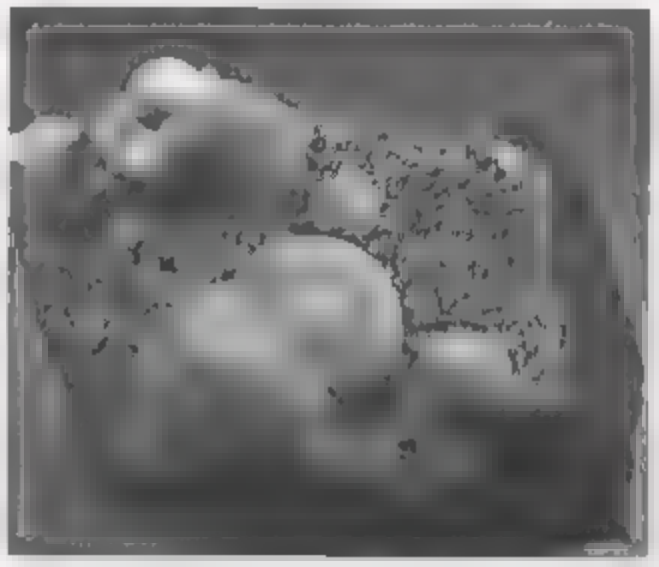
With the collapse of the market, the fraud and scam operations failed and turquoise faded from the world market. Luckily, true Native American artists emerged to create a whole new variety of superb jewelry combining turquoise with precious opal, gold, ivory, lapis, and the full range of gem materials. Meantime, legitimate turquoise stabilizing companies emerged to supply good material that was sold as stabilized turquoise, and the market gradually emerged stronger than ever.

One of the best stabilizing processes was developed by the Colbaugh family of Kingman, Arizona. They still supply quantities of fine material. Consider that without a stabilizing process, there would be little or no turquoise available for the lapidary and jewelry today. But with the diminution of the supply of natural gem rough, the development of useful stabilizing techniques has helped maintain a fine supply of turquoise so that today it is still a very important gem product.

One of the phosphates that seems ubiquitous in nature, but is hardly ever seen for sale, is wavellite. In most cases, wavellite is not a spectacular mineral easily sold by dealers. Therefore, it is less apt to be stocked by them. Still, a couple of localities among the dozens that produce wavellite have yielded quite respectable specimens in quantity.

Wavellite is an aluminum phosphate sporting such additional chemicals as the hydroxyl radical (OH), water, and fluorine. It forms in orthorhombic crystals, but I must confess I have only seen a few I could identify by crystal form. However, the common habit of wavellite is easily spotted. Fine needles arranged in radiating fans and balls. They may vary from almost colorless at the base of the crystals to a rich, dark green at the tips. Complete balls can reach over an inch in diameter and have high luster and that good green color. Wavellite can also be colorless to white, brown, yellow, and even blue. It can also form small stalactite clusters again showing some color zoning.

In this country, the better sources are undoubtedly in Garland and Montgomery counties in Arkansas. At the Mauldin Mountain quarry in Montgomery



Mount Ida, Arkansas, has long been a fine source of the phosphate mineral wavellite.

County, the material is found sporadically during operations there. The green radiating spheres form on brecciated or altered novaculite. The Dug Hill source in Garland County is similar and produced very fine half spheres on matrix, dark green in color and tightly clustered in the better specimens. Collectors still obtain Arkansas specimens, so once in a while, a small selection of specimens show up for sale at shows.

My favorite international wavellites are from the hydrothermal tin mines of Bolivia, most particularly Llallagua. The wavellite, a low-temperature species, was one of the last minerals to form, so other minerals from Llallagua are very often topped by tiny spheres of this white mineral. Among the better Llallagua specimens are slightly yellowish balls of wavellite on quartz crystals. Even larger spheres occur on matrix and can be found on cassiterite and several quite uncommon phosphate minerals, including paravauxite and childrenite. Specimens are uncommon, but in the last few years, dealers have realized that Bolivia is a good source of fine minerals and are putting more effort into obtaining minerals from this high Andes country. A recent example of superb phosphate vivianites was found there.

Bolivia is just one source of childrenite. It was first noted in quantity in the copper/tin mines of Cornwall, England, its type locality. These crystals were never particularly attractive small crystals of childrenite tend to be dark brown. However, Cornwall specimens occurred with several other uncommon arsenate minerals, including the world's finest eunoclase, superb olivenite, and the world's finest and very rare copper aluminum arsenate mineral, liroconite. The finest examples of this gorgeous blue mineral, a superb electric blue blade nearly 2 inches on an edge and freestanding on matrix, part of the Rashleigh collection, may be seen in the Royal County Museum in Truro, England.

One of the problems with childrenite is the considerable difficulty in distinguishing it from eosphorite. Childrenite is an iron aluminum phosphate, while eosphorite is a manganese aluminum phosphate. The two form a continuous series, as iron tends to substitute for manganese and manganese for iron. So when you look at a specimen, you cannot tell the degree to which these two metals have substituted for each other.

Though these two phosphates sometimes occur in the same deposit, the identification of each occured oceans apart. Childrenite was first identified in minerals from the Cornish mines back in 1823. In 1878, eosphorite in lovely, small, pink crystals showed up in the pegmatite at Branchville, Connecticut. Branchville was, in fact, one of the earliest of the phosphate-bearing pegmatites to be seriously studied in this country. Rev. John William Dickinson, for whom the phosphate dickinsonite is named, is credited with discovering several of Branchville's phosphates. He brought the Branchville material to the attention of Prof. Benjamin Silliman and other Yale professors back when Yale was a viable mineral research facility. Branchville today is completely off limits, but when I was doing fieldwork for my masters thesis, I spent much time at this small quarry enjoying the search for unusual and rare minerals.

Some of the finest eosphorites in this country were found at the Foote Mine, near King's Mountain in Cleveland County, North Carolina. This vast pegmatite has been one of America's better phosphate species sources. The Foote quarry is probably best known for its fairfieldite phosphate specimens in lightly tinted pink bow-tie clusters. Fairfieldite is another type species from Branchville (Fairfield County), Connecticut.

continued on next page

Phosphate Minerals *from page 43*

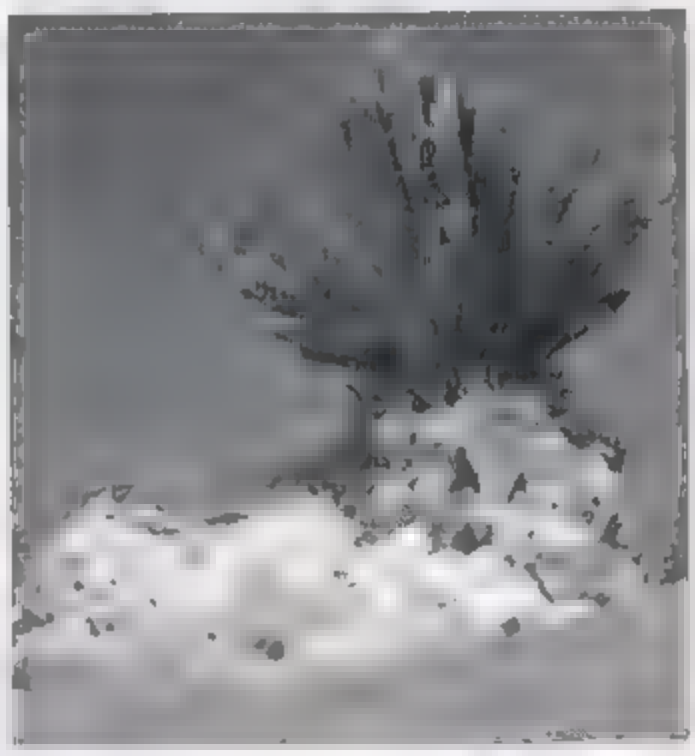
The Brazil pegmatites, famous for so many gem species and rare minerals, have been the most productive source of childrenite and eosphorite in recent years. For the collector, the most spectacular eosphorites came on beautiful, pink rose quartz from the Lavra da Ilha pegmatite, which sits in the middle of the Jequitinhonha River near Taquaral in Minas Gerais, Brazil. The site could be worked only during the dry season, as a rising river would flood the pits. Nonetheless, superb rose quartz heavily encrusted with diverging sprays of resinous brown eosphorite crystals were all the rage some 20 years ago. The crystals of eosphorite were never large a 2-inch crystal was quite unusual but the thickly clustered sprays on a lovely pink setting made for very showy and uncommon display specimens.

Equally exciting childrenite crystals have come from several other Brazil pegmatites, the most spectacular being the 4-inch tan to brown single crystals from the Joao Modesto dos Santos Mine near Linopolis in Minas Gerais. Some of the singles reached as much as 6 inches in length. What's interesting is they had to be X-rayed to determine whether they were eosphorite or childrenite. Another form of childrenite, this time from the Emo pegmatite near Galileia, occurred as small spheres.

You may have already noticed that the phosphate minerals tend to develop in companion pairs, for example turquoise-chalcosiderite and eosphorite/childrenite. Another pair of closely related species is vivianite and ludlamite. Fortunately, they are a little easier to distinguish because vivianite tends to develop in blocky or long prismatic crystals that can range in color from green to black. Ludlamite, on the other hand, forms small, tightly clustered green crystals that are distinctly different from any form of vivianite.

Vivianite's tendency to form prismatic crystals is so pronounced that some of the larger crystals can exceed 3 feet in length! You'll only see these in museums now, if at all, but a couple of decades ago, yard-long blades were found near Ngaoundere in what was then called the French Cameroons. They had formed after organic sediments in a bog and are decidedly unstable, one of the bad habits of some but not all vivianites. Soon after being retrieved from the bog, these giant crystals began to "feather," or split lengthwise. Their color, originally a dark violet-blue, soon turned black. The crystals were coated with plastic to prevent water loss and preserve them, but sealing them gave them an almost artificial look, so they were never popular. The larger crystals extant today are wired to the back wall of a display case at the Bureau of Mines, Paris. In a very stable environment, these giants will last for some time.

Quantities of flattened, radiating vivianite crystal clusters were found at Richmond (Henrico County), Virginia. Unfortunately, these violet crystals were unstable and had to be sprayed with plastic to preserve them for some time. Even so, they eventually broke down. Be sure you obtain vivianites from hydrothermal ore deposits, which are stable compared to those from organic sources. Incidentally, one oddity about vivianite worth noting is the several occurrences of this phosphate inside clamlike fossil seashells. The crystals can be upwards of an inch long in right clusters that nearly fill the open shell pair.



BOB JONES PHOTO HAUCK COLLECTION

The Lavre de Ilha pegmatite in Brazil produced a huge number of eosphorite specimens when it first opened.

Lightly tinted violet to dark-blue vivianite blades were found at the Blackbird Mine in Lemhi County, Idaho. The blades in diverging sprays reached as much as 7 inches in length, and they are stable. These blades showed prismatic vivianite's common tendency to curve, sometimes forming a 90-degree bend near the tip. They also show some splitting, but their color and condition seem very stable. It is only when vivianite forms in association with organic material that it is very prone to decomposition.

Mexico has been a wonderful source of fine vivianites in recent years, particularly Santa Eulalia in the state of Chihuahua. This is because mining here is ongoing, and random occurrences of fine blades up to several inches long are infrequently encountered.

The Bolivian mines have produced superb vivianites. Even today, some wonderful blocky crystals the size of your palm have been coming out and are currently available.

Historically, the mines of Eastern Germany, Cornwall, Trepca, Serbia, and several localities in Russia have produced vivianites, but these are almost never seen around today. The same can be said for the vivianites that used to come from Leadville, Colorado.

Vivianite's regular companion is ludlamite. It is less common, but more stable and certainly worth collecting. It forms green crystals that may be as much as 2 inches long. The crystals are almost always tabular, very often growing parallel to each other in flat plates or tight clusters. They have perfect cleavage, as does vivianite, so when you find a ludlamite for sale, study the visible crystal surfaces and look for flat faces that have a pearly luster. These are cleavage faces, since complete ludlamite crystals have a vitreous luster.

Many of the sources for vivianite also produce ludlamite: Idaho, Mexico, Cornwall, Germany, Bolivia, and so on. Since ludlamite is stable and forms in attractive clusters from a variety of sources, some of which are still being worked, you should be able to track down a decent specimen.

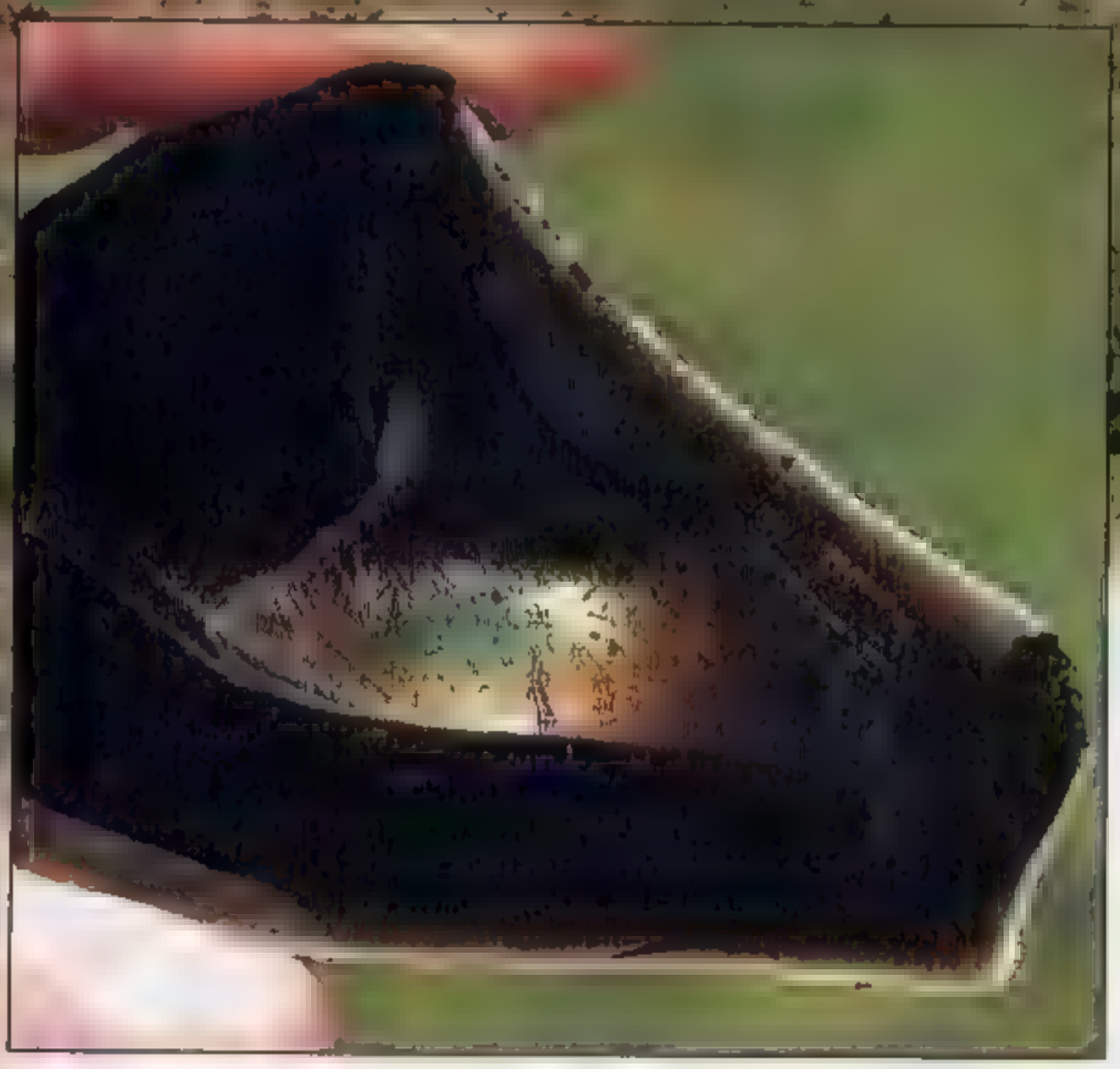
With more than 250 members in the phosphate group, this two-part series hardly scratches the surface. However, most phosphates either form in microcrystals or are rare enough that you will almost never seen them for sale. There are a few worthy of mention beyond what I have described. Of these, phosphophyllite is probably the most sought. Only a few specimens of this lustrous blue mineral came to light from Bolivia. The most spectacular is a 7-inch crystal brought out a couple of decades ago. Even the thumbnail-size crystals, usually twinned, bring $1,000 or more, so I doubt the Frugal Collector will ever have a shot at one. More common are such phosphates as scorodite, libethenite, tarbuttite, amblygonite, tsumebite, and a small group of radioactive secondary minerals, including autunite and torbernite. These last two are seldom for sale because of their nasty habit of giving off radon and radiation.

All in all, the phosphate minerals provide the Frugal Collector with copious opportunities to add to a growing collection. As with all minerals, knowledge of species and their properties is probably the most important ally the Frugal Collector has. So use good mineralogy books, subscribe to useful magazines, go to shows and talk to dealers and collectors, and experience the joy of intelligent collecting.

Faboulous Fire OBSIDIAN

Vibrant Colors and Unique Patterns Set This Stone Apart

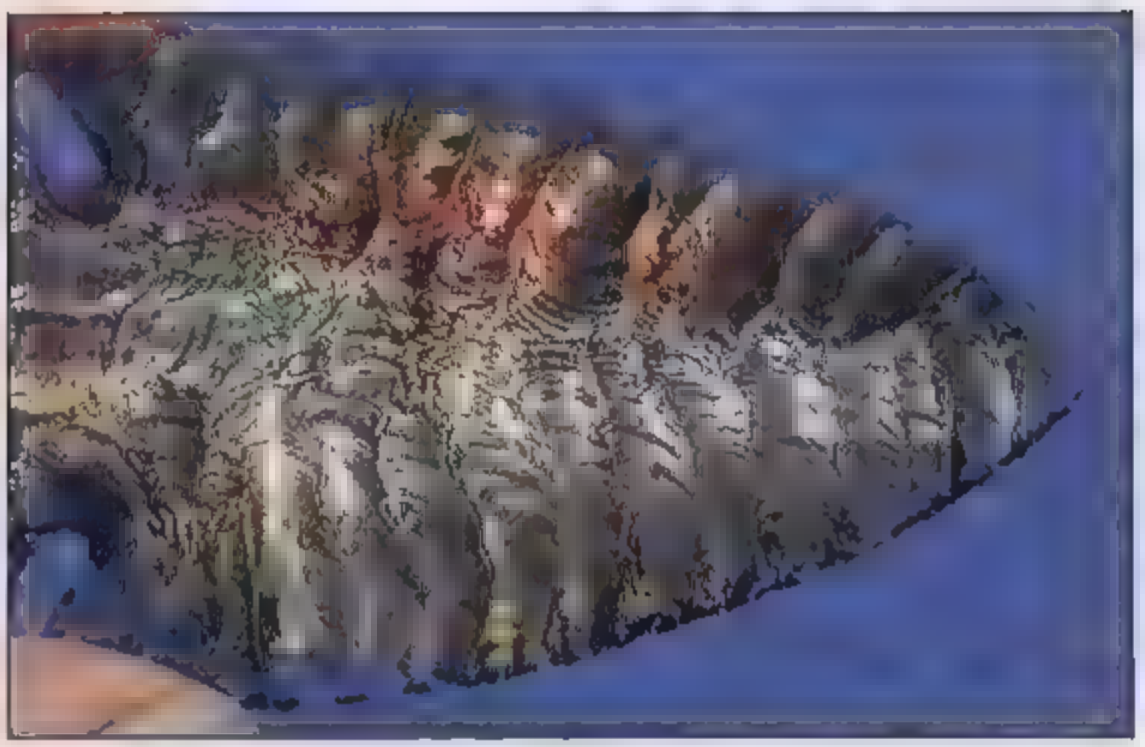
Story by James A. Miller



JAMES A. MILLER PHOTO

Microthin layers in the clear black glass cause flat surfaces to explode with every color of the rainbow.

Natural glass, obsidian, is most often found as a black, shiny rock associated with mature volcanic areas. But as most rockhounds know, obsidian also occurs in many other collectible types and colors. My personal collection of obsidian boasts jet-black, mahogany, midnight lace, gold sheen, silver sheen, pumpkin, snowflake, electric blue, pink lady, double-flow, rainbow, and Burns green specimens. Although I had heard of "fire obsidian," I had never actually seen any of this mysterious stone until recently



JAMES A. MILLER PHOTO

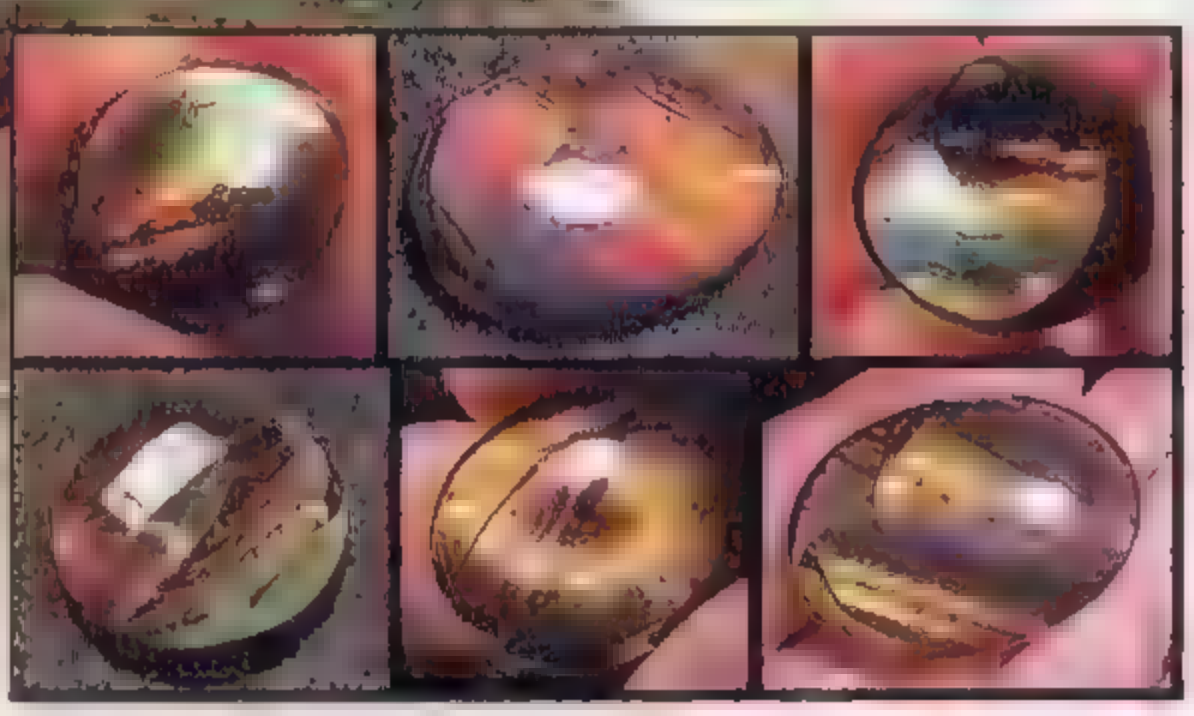
Careful flaking of the obsidian reveals the layers that hold the flashes of fire.

JAMES A. MILLER PHOTO

Lines marked on this obsidian sample identify two different fire layers within the stone.

JAMES A. MILLER PHOTO

The fire obsidian at the Careys' Glass Buttes claim occurs as thin, near-vertical dikes within pink rhyolite.



JASON HINKLE PHOTO

These fire obsidian cabochons show the beauty and variability of the fire layers.

Another rockhound and obsidian lover, Mike Booher, mailed me some samples of fire obsidian about a year ago. I was totally amazed when I opened his treasure box. Fire obsidian was unlike any obsidian I had ever seen before. The vibrant colors, unique patterns, and bright reflectance that emerged from this material were simply spectacular. I was hooked! I had to know more about this incredible material and collect some fire obsidian from the source location.

Mike informed me that the fire obsidian samples originated from a mining claim at Glass Buttes, Oregon. This popular haven for rockhounds was well known to me; I had made three previous trips there. I had collected many beautiful varieties of obsidian at Glass Buttes, but I had never seen anything like these samples of fire obsidian. This material looked like clear black glass at first glance, but it was much more than that. Within the glass were occasional microthin layers, most of which were relatively flat and nearly parallel to each other. On edge, these layers were nearly invisible to the eye. But in direct sunlight, some of these flat surfaces exploded with every color of the rainbow. This dramatic and surprising play of "fire" gave rise to the name of this unique and rare variety of obsidian.

With a little research, I learned that the mining claim at Glass Buttes was owned by Nadine and Don Carey of Bend, Oregon. I checked out their Web site and contacted them via phone and e-mail. The Careys obviously shared my enthusiasm for fire obsidian, and the wheels were set in motion for a field trip to their claim in May 2005.

Glass Buttes and its nearby neighbor Little Glass Butte are extinct volcanic domes that together comprise about 35 square miles in the high desert of eastern Oregon. Ground elevations in this area range from about 4,600 feet at the base of the two buttes to 6,400 feet at the summit of Glass Buttes Mountain. Almost all of Glass Buttes, including the area commonly visited by rockhounds, is owned by the Bureau of Land Management (BLM). Many varieties of obsidian are available to adventurous rockhounds who visit this interesting area. Although Glass Buttes offers abundant opportunities for collecting pretty obsidian, I was on a mission during this particular visit. I wanted to find some fire obsidian in its source location and unravel the mystery of this special type of stone.

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Fabulous Fire Obsidian *from page 61*

With great anticipation, I met Mike Booher at Glass Buttes beneath stormy spring skies. The main dirt road into Glass Buttes looked like a duck's playground, with myriad water-filled potholes surrounded by slick, red mud. I was very thankful that my four-wheel-drive vehicle was able to navigate the 2.5-mile obstacle course to reach the claim location.

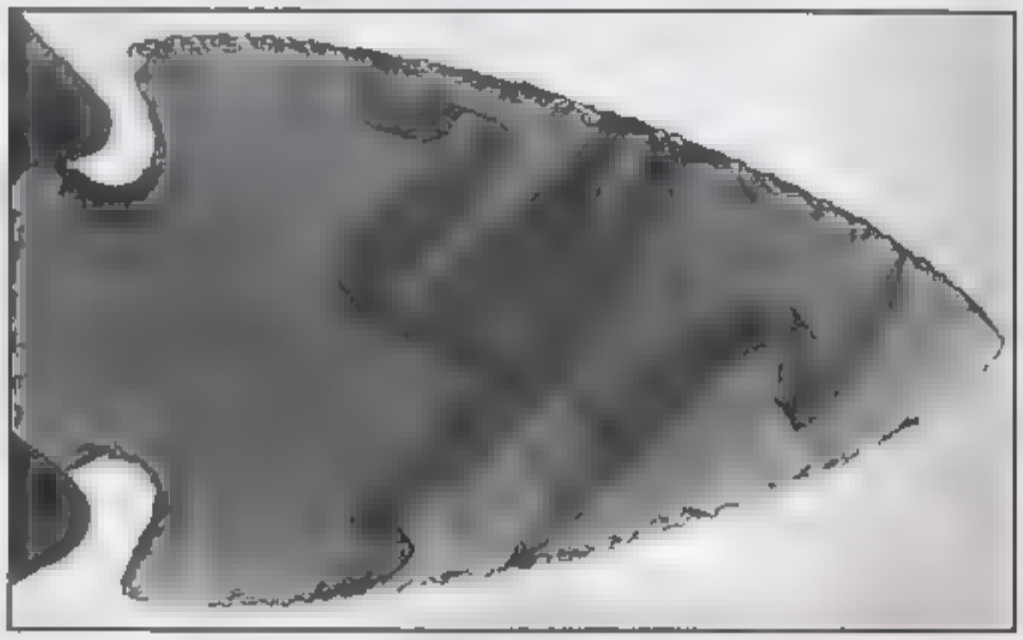
Nadine met us at her claim during a passing squall, and for a while we sat in our vehicles and swapped stories about past rockhounding adventures. Then she showed off some of her favorite examples of fire obsidian. They were incredible! When it stopped raining, we ventured up the steep foot trail to some fresh hand-dug excavations on her claim. Nadine showed us what to look for and how to determine whether the obsidian samples we dug contained the magical fire we were looking for.

Fresh from the ground, the weathered pieces of obsidian were dirty and typically opaque on the outer surface. Nadine showed me how to carefully chip off the outer edges of the stone and look for one or more faint, thin lines on the glossy obsidian surface. Sometimes, these lines were also visible on the outer, weathered surface of the obsidian samples. These lines occur where the microthin layers within the stone intersect the edges of the rock. With more careful flaking, you can determine whether some of the layers reflect the bright colors we were seeking.

Nadine was quite casual about how she tested the samples she had dug. She held the chunk of obsidian in her bare left hand and used a rock hammer to break off the edges. I believe that this woman is impervious to pain! Sometimes a sliver of razor-sharp obsidian would slice her left hand when she chipped an obsidian sample. Nadine didn't even seem to notice. On one occasion, she handed me a piece of obsidian for examination after she had tested it. The only color I could see was red. It was her blood on the rock!

Sunshine is a definite advantage when checking the samples for fire reflectance. Unfortunately, the sun was scarce during our visit to Glass Buttes. During cloudy periods, we sometimes looked for fire in the samples using Mike's bright flashlight. At other times, we would stockpile pieces of obsidian for later testing during the sun's brief appearances.

Part of the mystery about fire obsidian began to reveal itself to me as we dug samples for testing. The fresh diggings showed that the fire obsidian occurred as thin, near-vertical dikes within pink rhyolite. Typically about 2 inches to 8 inches thick, these dikes once conveyed molten obsidian to lava flows at the ground surface. The obsidian flows have long since eroded away, but these obsidian feeder dikes remain undisturbed and waiting in the underlying rhyolite. The remarkable clarity of the black obsidian in the dikes is likely explained by the fact that the obsidian congealed (solidified) below the ground, where it could not be contaminated by dirt, ash or other debris.



JAMES A. MILLER PHOTO

While most of the layers with fire are relatively flat, others are curved and folded

JAMES A. MILLER PHOTO

Small obsidian nodules, some of which contain fire, are found within narrow obsidian dikes that have been altered to perlite.

The geologic exposures also showed that the obsidian dikes are quite old. Various geologic studies indicate that the obsidian at Glass Buttes is about 4 million to 5 million years old. Some of the thinner seams of weathered obsidian have been altered to perlite. Small, rounded nodules of obsidian, similar to Apache tears, emerged from the perlite seams. Some of these small obsidian nodules contain fire layers and are perfect for polishing with a tumbler.

Near the original ground surface, the rhyolite was quite weathered and relatively easy to dig. However, the near-surface obsidian was also weathered and present only in pieces up to a few inches across. As we followed the dikes deeper into the ground, the pieces of obsidian gradually increased in size. The largest pieces we found were about 6 to 8 inches across from a depth of perhaps 5 feet below the original ground line. Although the pieces got larger with depth, the digging got a lot tougher, too. Prying out chunks of obsidian that are embedded in tough rhyolite is not easy!

Interestingly, only some of the obsidian dikes contained the microthin layers that produce fire. One dike we sampled contained only clear black glass. Another dike contained layers within the glass, but these layers did not produce any fire. Other, somewhat wider dikes contained thin layers that were swirled into intricate folds similar to midnight lace obsidian; this was pretty material, but not what we were seeking. However, once we found a dike with fire, that dike continued to produce pieces of obsidian with the telltale lines and layers that sometimes displayed fire reflectance. In fact, nearly every piece of obsidian that I collected from the "hot" dike rewarded me with one or more microthin layers that displayed rainbow colors or a mirrorlike reflectance with colors of copper, silver or gold.

I found that the microthin layers within the obsidian were generally aligned nearly parallel to the orientation of the obsidian dikes. I believe this gives a clue as to the reasons for the micro-thin layers within the glass. I observed that the obsidian dikes often split around pieces of the rhyolite host rock, and then rejoined again. I suspect that a thin layer marks each junction where the glass rejoined in its upward journey toward the surface. The layers are like tree rings in that they record the number of times the molten glass within a dike split and rejoined. The high viscosity of the obsidian magma prevented the glass from mixing, keeping the layers separate. The microthin layers also were stretched and extended as the molten obsidian moved slowly toward the surface. Many of the layers contain tiny parallel lines on the surface of the layer. These lines are oriented in the direction of the original flow path of the molten glass. The lines were "frozen" in time when the molten obsidian cooled and solidified.

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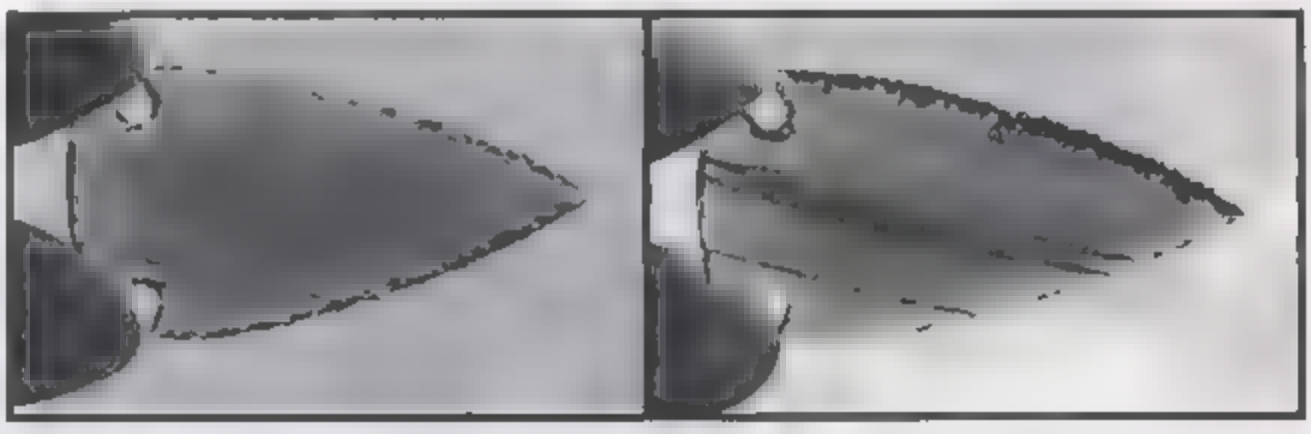
Fabulous Fire Obsidian *from page 63*



JAMES A MILLER PHOTO

The seven microthin layers in this arrowhead are almost invisible from the side but are more visible at a slight angle.

The amazing play of reflected colors from the microthin layers is likely also related to stretching of the layers when the obsidian was molten. The color reflectance on the layers appears to be a purely physical phenomenon; the colors do not appear to represent exotic trace elements or strange mineral inclusions in the glass. More likely, the tiny grooves and pits on the surface of the layers result in a light interference effect known as diffraction. A similar process leads to the familiar play of colors on the surface of compact discs.

On the second and final day of our visit to Glass Buttes, we were joined by Nadine's husband, Don. While Mike, Don and I continued collecting fire obsidian from the hot dike, Nadine walked around and sampled other portions of her claim. Before too long, she found another obsidian dike about 100 yards away with some spectacular fire. Later in the day, Don and Nadine showed us other parts of their claim where fire obsidian had been collected. Although fire obsidian has been found in other parts of Glass Buttes, it seems to occur in greatest quantity and in best quality on the Careys' claim.

Fire obsidian can be cut and polished into spectacular cabochons. With great care, it is also possible to make very impressive and unique arrowheads from it. For best color visibility, a minimum amount of obsidian should cover the color layer. But be careful. If you get too aggressive and remove the color layer accidentally, it will be lost forever!

Every layer of fire seems to be unique. Some layers reflect many colors in bands and patterns, with sharp boundaries between the colors. Other fire layers have colors that grade from red to green to blue to yellow, similar to an oil slick on water. Still other layers reflect only one color, such as purple or deep red. Sometimes, the color patterns seem to overlap each other like frost crystals on a window pane. Some microthin layers reflect colors on both sides, while others display fire only on one side. The color layers can occur as single, isolated surfaces in the stone. Often, however, several color layers are stacked one on top of another so close together that it is not possible to isolate them individually. There is no end to the variety of color patterns and abstract shapes that emerge from fire obsidian!

It is a definite challenge to isolate the color layers for display in cabochons, arrowheads or free form rock sculpture. After washing the rock samples thoroughly, actual or potential color layers should be marked on each piece of obsidian. Sometimes, this requires additional chipping on the edges of the samples in order to track the microthin layers all the way around the samples. I mark the layers of interest with a metallic permanent marker or a grease pencil. The next challenge is to orient the rock in a diamond saw and cut the stone parallel to the color layers, without trimming off the fire. I usually make my cuts well outside the target layers just to be safe. After that, patience and experience are what you will need to create a fire obsidian masterpiece.

Access to Glass Buttes is via U.S. Highway 20, approximately midway between the communities of Bend and Burns. Turn south on Obsidian Drive (road sign no longer visible) at milepost 76.9 to access this fascinating volcanic area. Several miles of rough roadway with numerous branches and four-wheel drive trails provide access to this wonderland of sage and juniper.

Except on legal mining claims, public collecting of obsidian is allowed at Glass Buttes within the limits set by the BLM. Because the fire obsidian occurs mainly on the Careys' mining claim, permission must be obtained from the claim owners before any collecting can be done within the limits of their claim. More information about the Careys' fire obsidian claim can be found on their Web site, www.goldnugget.com/DryFire/index.htm. Rough samples of fire obsidian or finished cabochons can be purchased directly from the Careys.

A Better Rock Hammer

Larry Harrison Makes Custom Tools for Serious Rockhounds

Story and Photos by Lance Strong

The term "craftsman" usually brings to mind the fine lapidaries, gem cutters and metalsmiths featured in the Craftsman of the Month section of *Rock & Gem* magazine. There are, however, those whose skills in fabrication make it possible for the rest of us to find, gather and collect the stones, gems and fossils we so enjoy and make (or have made) into the jewelry we admire.

I'm speaking of those craftsmen who handcraft the tools we use in the field. These days, we are very fortunate to have a selection of quality hand tools provided by the big names in the industry. Many hold up well and fulfill our needs, but some do not. It's very frustrating to be many miles (or days) from a tool store when your hammer or pick breaks in the field.

Many of us haunt the military surplus dealers and look for tools that will fit our needs and hold up properly. Recently, I used a stout Swedish military shovel to dig for Montana sapphires. It's extremely strong and holds up well. It should, though, as it's used to dig out stuck Mercedes UNIMOG vehicles used by the Swedish army!

Some tools feel fine in the hand if you're an "average" male, whatever that is, but wouldn't it be nice to find the rock tool that better fits your body size or is made with the combination of features that best suits your particular collecting habits? This is where the custom toolmaker with a knowledge of steel and the demands of rockhounding really shines.

At the Tooele, Utah, rock show a couple of years ago, I noticed many people walking around with new rock hammers of several designs, all sporting bright yellow handles. It didn't take long to find the seller, Larry Harrison of Bountiful, Utah. I found that Larry was not only the seller of the tools, but also the manufacturer. Larry told me he had made them for 30 years and given them to friends. They were so happy with the tools' performance that they talked him into making and offering them commercially.

He showed me his many different design combinations and told me that he hand-forged them all of a wear-resistant steel made by the Astralloy company. It's an air-hardening (tempering) alloy that's extremely tough and used for such high-wear needs as bulldozer blades. My wife, JoAnne, bought the model with a chisel blade and round hammer that seemed to be perfect for Utah trilobites and Wyoming fossil fish as a Christmas present for me.

Later I met Larry at his home and he showed me small one-hand types like mine, as well as the "standard" pick and hammer and a fork with pick. I placed an order for a fork with-mattock model to be used for topaz, garnet and sapphire hunting. Its other life would be as a gar-

dening tool, since my "best quality" Japanese hand hoe didn't hold up to Utah clay gardening

At the end of the following March, I visited Larry to watch him forge the various blades. He only forges in the springtime and autumn, when it's not too hot outside to work over his homemade furnace. The furnace (forge) is made from a truck wheel, and a shop vacuum forces air into the coke (carbon fuel) more efficiently than the hand bellows of times past

Larry wisely donned heavy coveralls, thick gloves, and safety glasses before he began work. He heated the steel alloy to the proper shade of red (years of experience tell him when the color's just right), and then he started pounding heavily with his homemade hammer on the red-hot steel. If the steel's not hot enough, it will not be plastic enough to work. Too hot, and pieces of steel flake off

It takes more than one heating and series of hammer forgings before the proper shape is accomplished. Much arm strength is required, as well as accuracy to hit the steel exactly where it's needed. These skills used to be found in the town blacksmith, but now reside only in farriers, who make and modify their own horseshoes, and custom knife forgers.

There are no secrets to forging rock tools, just plain hard and hot work. "Anyone dumb enough to do it is welcome to," Larry says. It's not inexpensive to set up. Besides the furnace and coal or coke for fuel, you will need high-quality steel stock, a cutter to slice off the forgings to the proper size, grinding wheels, welding equipment (and skill), handles, industrial strength epoxy, and paint. When I told him he needed a name or logo stamp like a custom knife maker he replied, "Everyone knows who made it."

Larry used to do his own welding, but he now has master welder Vern Woodward do it for him. Larry guarantees the forging, steel quality, and welds. The steel, like all working steel tools, will wear with use, and that's to be expected. He won't guarantee the handles, but has had no problems with them since he recently switched to a commercially made yellow fiberglass. In the dry West, wood handles can shrink, but that's not a problem with the fiberglass, of course. The heads are attached with the best professional-grade epoxy he can find—stuff used in heavy industry, not the grocery store variety—and they stay attached. After the final grinding of the steel and welds, the tools are painted black to help retard rusting of the carbon steel

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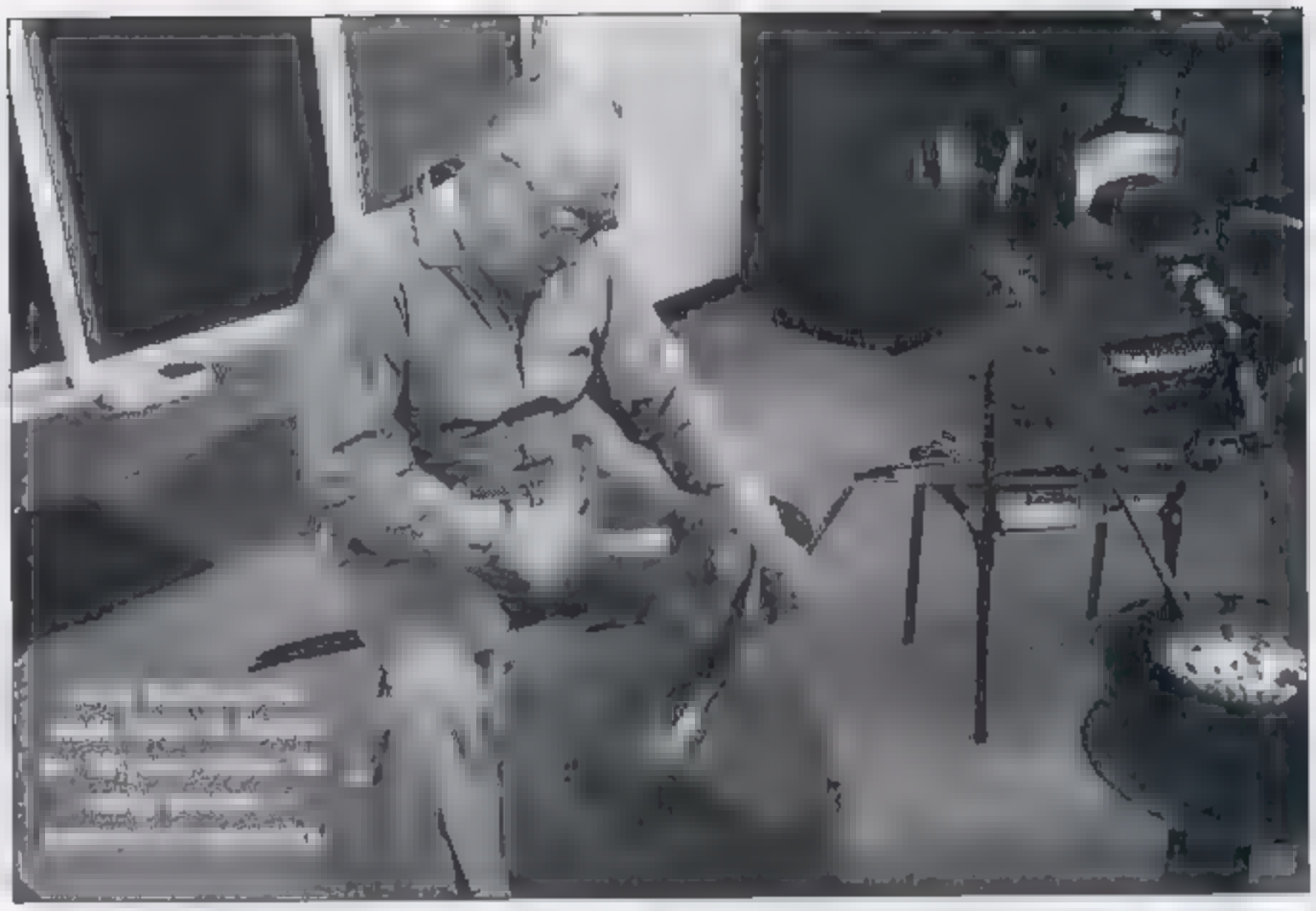
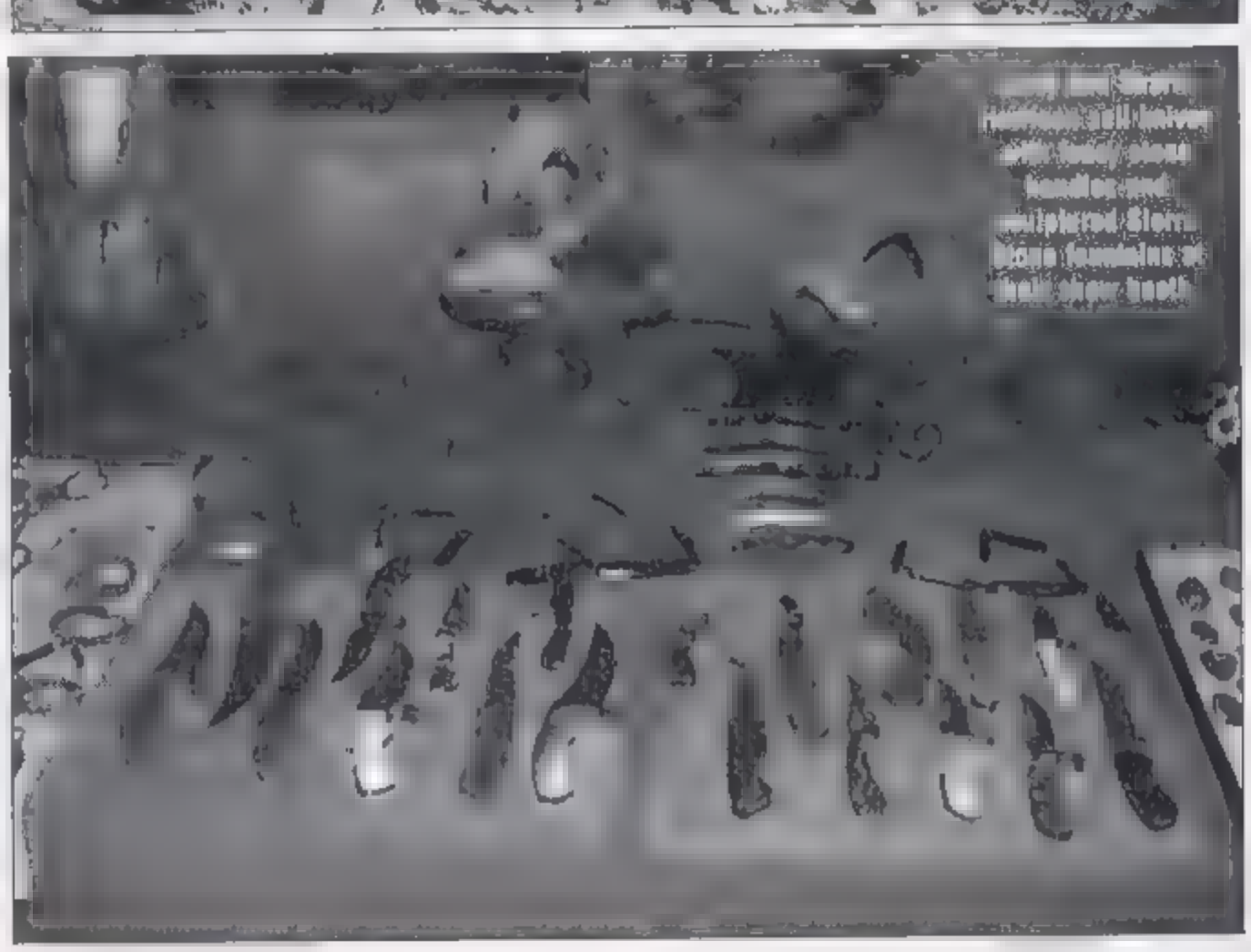


Russ Fjelstad, of Algoma, Wisconsin, uses Harrison's fork-mattock tool to dig for sapphires in Montana.



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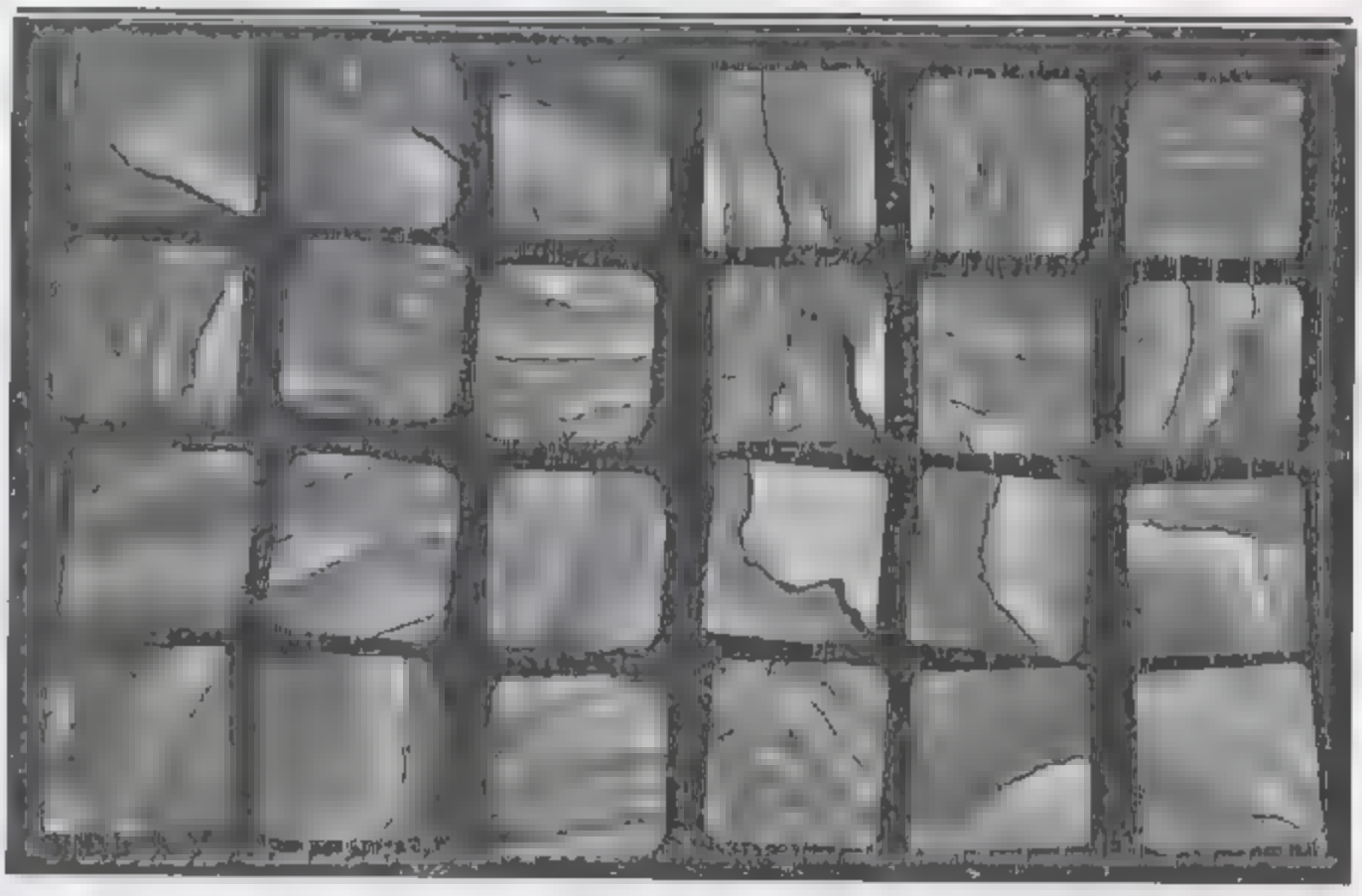


The Sierra Stone coasters are left unsealed so they can soak up moisture from beverage containers.

Sierra Stone is a porous sandstone or limestone/sandstone mix from Arizona.

One model I really like is a walking stick that unscrews in the middle so the hand-pick handle can be used separately. It's built for lighter use and many women like it for its weight, but I'd like one custom made for my weight. Larry may still use wood for that model, but it was worked out OK. Fancy tropical woods can be made into handles, and these make fine presentation tools for that special rock club award.

I told Larry that I've had good luck with commercial chisels holding up, but that they're the wrong design. I really need some that are quite flat, thin, and rather wide for fossil splitting. He showed me some he makes for commercial marble splitters, and they're just the ticket. Larry's hand tools and chisels have been used hard by my family, friends and me in the deserts of Utah and Wyoming and the Sapphire Range of Montana. They are still working perfectly and show less wear than most commercial tools I've used. He also makes large pick-mattocks with 36-inch handles that I'd like to own, but all were ordered by mines in Virgin Valley, Nevada, for digging opal.

Besides strong hand tools, Larry and his wife, Sharla, make sculptured fountains and drink coasters from Sierra Stone, a sandstone or limestone-sandstone mix. The stone is from Arizona and is thought to have been laid down by wind and then percolated through by water. Larry heats the stone in an oven of his own design to darken the iron coloring the stone.

The drink coasters are left natural (unsealed) to soak up the moisture from sweating glasses and bottles. The fountain and candleholder stone is sealed with a clear sealant so it won't absorb the water or candle wax. Due to the natural patterns of the stone and the core drilling and sandblasting done by hand to make them, each piece is a one-of-a-kind creation.

Sharla told me they attend nine shows each year, including Quartzsite. She makes fine, unique jewelry and Larry also makes knives with fancy stone handles that are epoxied and pinned in place. The blades are made from 440C stainless steel and are commercially heat treated. He normally does not provide sheaths for them, but can arrange for sheaths to be made for the customer at cost from Simon's Custom Leather in Salt Lake City, Utah.

Larry and Sharla Harrison do a large mail-order business and can be contacted at 360 East 2200 South, Bountiful, UT, 84010 or via phone at (801) 292-5413. You can do as I did, though, and just follow the trail of yellow-handled custom rock tools back to their source when you see them being carried at a large rock show! ☆

The problem was that in the first 14 years of operation, no attempt was made to separate the mineralized vein rock from the black slate. Numerous irregular veins of quartz cut through the slate, some closely spaced and others sparsely distributed. Although Bradley had planned to have the waste rock sorted out before sending the ore to the mill, this wasn't done in the early operation of the mill. Hand sorting discarded about 50 percent of the rock. The white quartz was easily identified, and the dark slate was conveyed to dumps on the steep hillside. Railroad cars carried waste rock along the beach, where it was used to create a waterfront for Juneau, and barges dumped loads into the channel. The city also used the rock for road building.

"This was the natural shoreline along Front Street," museum curator Wyatt said, pointing to a red-dotted line on a Historic Downtown Juneau brochure. "They built out on pilings and then filled it in. Part of Juneau is built on waste rock. This used to be the native village where they pulled their canoes up on the beach. The A-J waste rock dump a mile south of town has become an industrial area."

Exploration below the main workings found a rich ore body, and in 1933, the price of gold went to $35 an ounce. The A-J had bought the old Treadwell properties in 1928 and the Alaska Gastineau in 1934. The Gastineau lode was connected by tunnel to the A-J, and its ore became a third or more of the mill feed. During the 1930s, the A-J employed more than 1,000 men. Most miners lived in town, and the economy boomed. Many businesses stayed open all night for the convenience of men on the night shifts.

World War II brought the mine to a close. Known ore reserves could have kept it open, but the shortage of labor, government closure of nonessential mines, and rising union wages spelled the end. Ore grades had fallen to 0.033 ounces gold per ton, about one part per million. In 1948, the Alaska Juneau Gold Mining Co. ended its run in Juneau. The low-grade ore body had been mined over a horizontal distance of 2.5 miles and vertically for 2,800 feet. The A-J Mine, including the Ebner and Perseverance mines, produced 3.5 million ounces of gold, 2.2 million ounces of silver, and 45 million pounds of lead. The machinery and equipment were eventually sold, and a fire destroyed the mill building in 1965. Only the concrete foundations above Juneau are a reminder of its location. The Juneau Mining Museum at the old Last Chance mine camp up Gold Creek has displays about this world-famous low-grade gold mine.

One of the original Treadwell stamp mills has been set up at the entrance to the Treadwell mine trail.

On Juneau Isle, locally called Mayflower Island, above the Douglas boat harbor and near the trail to the Treadwell Mine in South Douglas, Jane Albrecht answers questions and provides resource information at the Juneau Mineral Information Center.

"We get a lot of people wanting to find out about the historic mines here," she said. "And prospectors looking at old claims to find out if there are any open areas. Someone might ask 'What can you tell me about the Friday Mine?' We have the mineral property files on each occurrence."

From a pile of maps on a table, Albrecht showed how land status was marked out as "state or federal land closed to mining," "Native selected," or "state land open to mining," and X's pinpointed known deposits.

"Our focus is minerals and geology," she emphasized. "The library was established to serve all Bureau of Mines in Alaska. When the Bureau closed, the Bureau of Land Management retained the geology and mining library in Juneau to serve the mineral assessment staff and as a resource for the southeast Alaska community." The BLM geologists and mining engineers survey, map, and sample mines and mineral deposits, evaluate the mineral potential of federal lands, and conduct economic, engineering and environmental studies.

In a "Rocks and Minerals of Alaska" display near the building's foyer were examples of gold in quartz with dark blebs of sphalerite and galena from the A-J Mine. Once an amusement park and dance pavilion when the Treadwell boomed, spruce-covered Mayflower Island overlooks the beach where prospectors placer mined surface gold from the deep veins.

"From here you can see pilings leading to a pump house for water to be used in the mill and for fire control," Albrecht noted. "On the beach you can see the pilings for the natatorium and dining hall. There are shards of China plates in the sand. People walk out on the trail, and then they come in here and dry out for a while." For more information, contact the Juneau Information Center at 100 Savikko Rd., Douglas, AK 99824, (907) 364-1553, or http://juneau.ak.blm.gov/LIBRARY/Library.htm.

Alaska's history began well before gold was discovered in Gold Creek in the mountains behind Juneau and on Douglas Island, but the flood of people and the long-term employment from the mines brought stability and a thriving town. Hiking trails, tours, and the city museum are ways to investigate this early development of Alaska. Waste rock along the harbor and mill tailings in the beaches still contain gold. Streams open only to panning (where not under claim) include Gold and Sheep creeks and Bullion and Ready Bullion creeks on Douglas Island. Serious prospectors can research mines and prospects at the Juneau Mineral Information Center. Located in the "panhandle" of Southeast Alaska and accessible only by air or the Alaska Marine Highway Ferry System, Juneau's gold brought prosperity and permanence to this rainforest region.

The "new" office building of the Treadwell Mine was completed just before the 1917 mine cave-in.

LAPIDARY LORE AND MORE

by June Culp Zeitner

What's in a Name?

Have you ever wondered why some authors choose to use pseudonyms or pen names, and how those names are selected?

I used to think I could spot a pen name immediately, until I read articles by *A Worth Hobby* turns out he was real Others that fooled me were *U R. Jolly* and a signature on a letter to the editor, *Me and Pa* That was puzzling until I was told it was short for *Maine and Pennsylvania*

Why do writers use pen names?

1. The author wrote an unkind remark about a contemporary

2 The author did not wish to be quoted on his information or opinion

3 The author already had two articles in the same issue.

4. The author expressed controversial ideas.

How is a pen name chosen?

1 The author may use a friend's name with permission.

2 The author may use the name of an ancestor

3. The author may use a name that has some relationship to the subject

4. The author may use a family name or nickname.

Did I ever use a pseudonym? Of course. After all, I have been writing for publication since the early 1950s, so it would be strange if I hadn't had occasions to use a pen name

First, I wrote several articles in my husband's name, *Albert Zeitner* He was my partner on all my field trips Those pieces were for *Lapidary Journal* in the days when the hobby was at its height, Pansy Kraus was editor, and I was her editorial assistant The magazine was thick. There were many ads that had to be balanced by editorial features, and articles were coming in very slowly. Pansy said she thought all the rockhounds were out rock hunting I became glued to my IBM

My second pseudonym was *Cynthia Cooke* My grandmother, called Jenny, was the daughter of the Rev. Horace Cooke, whose great-grandfather, John Cooke, came over on the Mayflower Grandma Cooke raised seven children, played the organ for the church and was in charge of "laying out" the bodies of deceased members for burial In the 1880s, there were no funeral homes in rural Michigan

Someone had given Grandma a box of copper ore from northern Michigan She used it as a border around her hollyhocks. Grandma was very strict She wouldn't allow us to play in her big front yard on Sundays. However, she did let us sit in the yard and read an approved book

My third pen name was *Steven Ailes*, the name of my grandfather He was a millwright His work with stones in New York, Pennsylvania, and Michigan involved huge millstones. His grandfather, also Steven Ailes, had emigrated from Wales. Grandma claimed the family's musical talent was from its Welsh heritage Grandpa was in his late 80s when I knew him best He would sit in the rocking chair by the old potbelly stove singing or humming old songs. He was a little foggy about the origin of some songs. One day, in a pause from singing, he told me he had written a song He said it was "Red River Valley," a song already older than he was. Grandfather was absolutely convinced it was his My uncles Fred and Frank sang duets and included "Grandfather's song" in their repertoire. How proud he was! Grandfather outlined his big raspberry and strawberry patches with well-chosen rocks.

I also contributed quite a few items to the work of that popular author *Anonymous* These were things like obituaries, announcements of changes in dates for shows, statistics, new e-mail addresses, and notices of new lapidary machines

I have a new pseudonym ready to use when it is appropriate, which no one will ever guess.

While I'm on the subject, I must include my mother Mom caught the rockhounding disease from me She started by learning the names and main location and use of every rock in her extensive rock garden and flower border She knew the scientific names of all the flowers in her big garden, so she could do no less for her rocks At the age of 80, she asked for a tumbler for Christmas I gave her a small one, but doubted that she'd have the patience to get good results. Her first batch of stones was flawless and glistening She was already a favorite of all the neighborhood kids, so when she handed out bright, shiny stones along with her date-pecan cookies, her young audience of admirers more than doubled

Mom joined the local rock club at age 82, and always took a show-and-tell

The first time I wrote under a pseudonym was in my husband's name, Albert Zeitner, in the early 1950s.

specimen She was always early for the meetings. She would station herself in the hall by the door to the meeting room and greet every person who came with, "Good evening I'm so glad you could come to our meeting tonight I'm June Zeitner's mother"

I don't think half of those she greeted had ever heard of me, but at least they pretended great interest because she was the quintessential "little old lady" 5 feet, 2 inches tall, with her hair done up in a bun and wearing a blue dress with crocheted collar and a rather long skirt, a pearl necklace, and a white shawl Always with a friendly smile on her very fair face, she took long walks. If she decided to cross a busy street, at least three Boy Scouts would appear to escort her She was close to 99 when she died.

Someone once asked me if I had an alias. No, an alias is not the same as a pseudonym An alias is a name adopted by someone who wants to hide for some reason A rockhound doesn't need an alias, but pseudonyms are often used. Here are some: Rock Hunter, Maren Bakker, Rockaholic, Bead Cat, Snake River Pete, A Rockateller, Whittling Jack Ima Gem, Wire Wizard, Xtal, Geodone Rocky Stone, Agate Annie, and oh yes, June's Rockyworld

Chalcedony

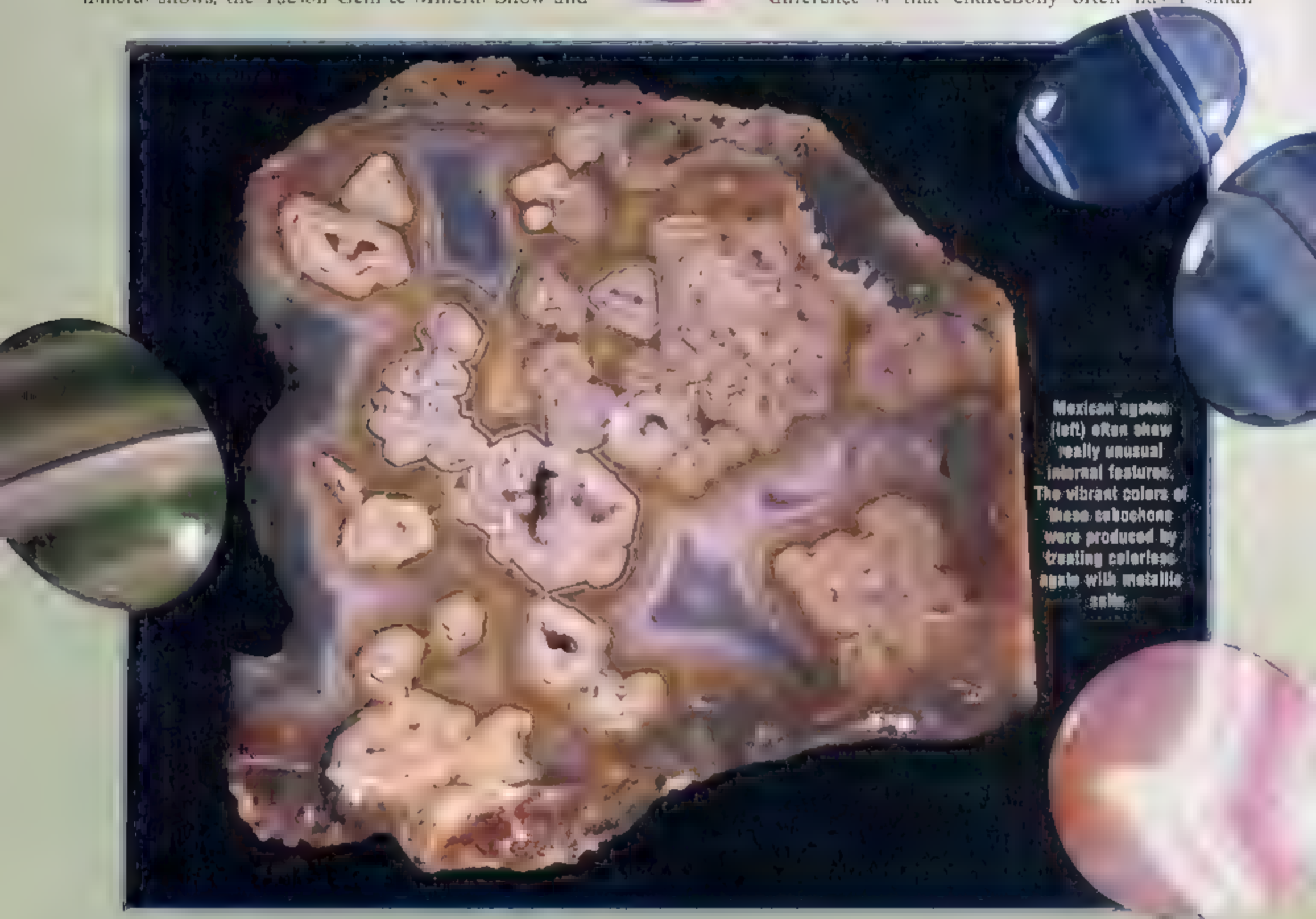
Colors and Patterns Explain Its Popularity

Story and Photos by Bill Evans

Finely crafted carvings, bright cabochons, shiny spheres, and many fine lapidary works done in some variety of chalcedony grace many a display at local and federation shows. Chalcedony gem work has been with us since gem and mineral shows began.

Chalcedony agates are a regular part of shows, but never a featured or advertised special display. However, when two of the world's greatest gem and mineral shows, the Tucson Gem & Mineral Show and Germany's Mineralientage Munchen, feature fine agates as special displays or choose agate as a show theme, you know there's something special about this chalcedony quartz gem.

Chalcedony, from which agate and a variety of quartz types are derived, is classified as quartz even though it is nothing like the lovely hexagonal prisms of crystallized quartz we enjoy. While these two varieties of quartz are visibly and distinctly different, both are composed of silicon and oxygen in a one-to-two ratio (1:2). A minor chemical difference is that chalcedony often has a small



Mexican agates (left) often show really unusual internal features. The vibrant colors of these cabochons were produced by treating colorless agate with metallic salts.

Agate

amount of water or the OH hydroxyl radical as part of its structure.

The visual or physical difference between crystallized quartz and chalcedony is obvious, but the reason for it is quite subtle. The secret is in the structure of the chalcedony. It looks massive, but is actually composed of crystals that form microscopic radiating spherules! The crystals that make up a specimen of chalcedony number in the tens of thousands, even millions, per inch. Even though they are not visible to the unaided eye, they are crystals. Their form is unusual, for they are elongate fibers rather than discrete crystals. How important this is will become apparent as we go along.

When the crystal of any mineral develops internally it does so around a set of geometric axes. Scientists group minerals according to the number of axes and their angles. A cube of galena, for example, has three axes at right angles to each other, all the same length. A quartz crystal develops around four axes. One axis is longer than the other three and is called the C axis; the other axes are at right angles to the C axis and, in a perfect hexagonal quartz prism, are of equal length to each other. Normally, the longer length in a quartz crystal follows the C axis.

This is not true of the quartz crystal fibers in chalcedony. This cryptocrystalline form of quartz develops microscopic crystal fibers that are tightly packed together. Instead of having the longer dimension along the C axis, the fibers grow longest at right angles to the C axis. This unusual circumstance gives the fibers an important twist as they develop.

These long, microscopic, twisting quartz crystal fibers grow in parallel or near-parallel bundles. No matter how tightly they are packed together, the twist leaves microscopic channels and threadlike openings, which fluid impurities can invade. This porosity, common in the layers or bands of agate, provides perfect access for mineral-bearing solutions, which is what brings color to agate bands as they form.

Impurities are the key to chalcedony's popularity, whether the color is introduced after the formation of the chalcedony agate or is part of the original agate-forming solution. The Southwest American desert floor is covered with small, white, roselike chalcedony growths. They're pretty, but not exciting to the lapidary because they lack exciting color patterns. But add color, and these common chalcedony "roses" suddenly become more appealing and attractive. Impurities in the internal structure diffract light into a rainbow of colors, and that common chalcedony rose becomes a desirable multicolored gem we call fire agate. Metallic impurities also impart the vibrant colors we see in chrysoprase, jasper, gem silica, and fortification agate.

Agates come in myriad forms: moss, dendritic, plume, fire, onyx and more. But the most common and most beautiful example of a chalcedony agate gem is banded or fortification agate. The term "fortification" best describes the agate patterns, which look like castle ramparts. These colorful beauties are found in almost every country.

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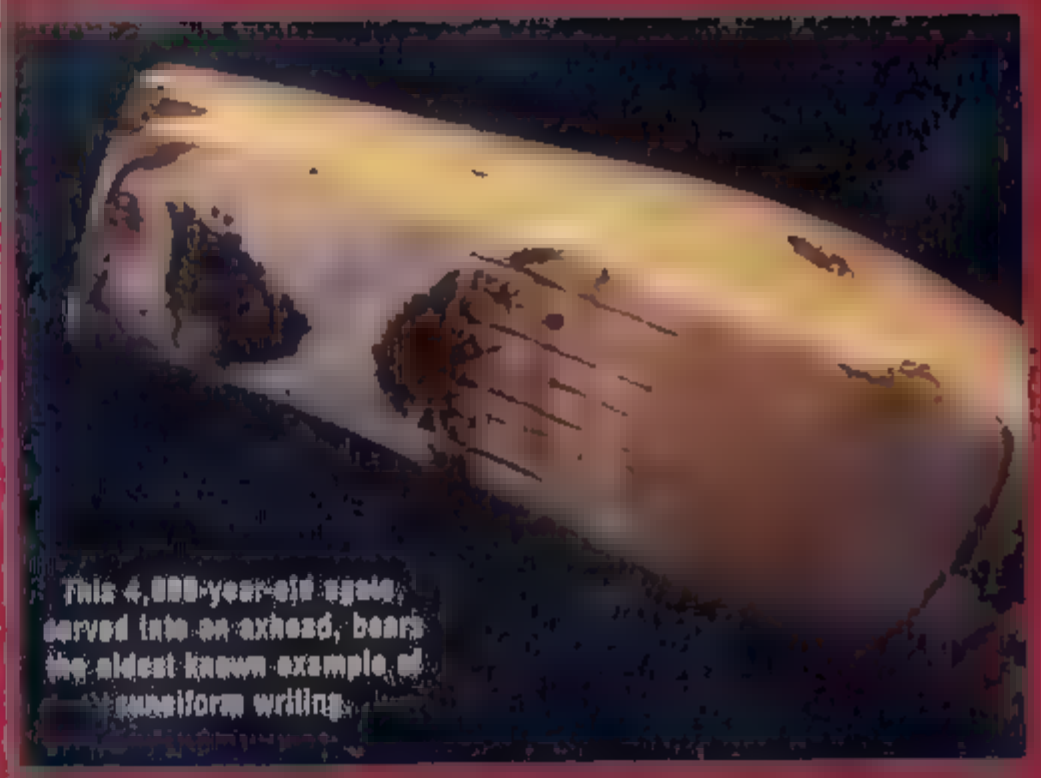

Chalcedony Agate *from page 81*

Just where the first agates were collected is unknown, but the gem derives its name from the Achates River in Sicily, along the banks of which fine agates were found. We know the Phoenicians traded in agates, and that the stones were prized by the Egyptians. Superbly carved agates have been found at a number of archaeological sites in the Near East, many dating to well before the birth of Christ. The famous 3rd-century Gonzaga cameo, a human profile carved in a three-color agate, is now in the Hermitage in St. Petersburg. As luck would have it, while working on the video "Russian Gem Treasures," we had the privilege of actually holding that precious jewel.

Superb carved agates were common in classical Greece: carved cameo gems for personal adornment and lovely small bowls, often with white figures in high relief against a dark brown or black background depicting scenes of gods and goddesses at play, were artfully carved from banded agate.

The Romans obtained agates from the Cassiterides (present-day England), as well as Sicily, Europe, Egypt, and the Near East. Bulgaria is particularly blessed with agate deposits, as is the Caucasus region of Georgia. There's even some thought that the Romans mined agates along the Nahe River, which runs through the modern-day gem region of Idar-Oberstein. More likely, they developed a brisk trade with the Germanic tribes to the north.

Idar-Oberstein emerged as the leading source of agate carvings in the 1500s. Fine banded agates were mined from the ancient basalt flows of this famous German region. Artisans using water-wheel power shaped and carved the agates into fine works of art.

Within 200 years, Idar Oberstein had nearly exhausted its agate supply, so local artisans set out to find a new supply of banded beauties. In the mid-1700s, a huge source of agates was found in the Rio Grande do Sul region, which straddles the Brazil-Uruguay border. Huge quantities of banded agate occur there in a volcanic setting. The quality of the agates ranged from drab, mostly gray fortifications to colorfully banded, gem-quality agates. Agates from many other regions are a few inches in diameter, while many Brazilian agates are upwards of 10 inches across.

While Brazil's colorful agates are highly prized, it was obvious the less colorful specimens had to be color treated to make them marketable. Taking advantage of the natural porosity of banded agate, miners dyed the less attractive agates with a variety of metallic salts and used them to carve inexpensive objects.

If you have visited gem shows or gift shops and seen a plethora of very colorful, sometimes garish, banded agate from Brazil, you may doubt that Brazilian agates can be drab and dull. Obviously, the colors you see are not natural. The violet, pink, blue, red, yellow, and other colors have been introduced into agates that lacked color. Treating these lower grade agates has made them marketable.

Agate dyeing is a universal practice that can be accomplished in your own backyard, if you are careful. It's certainly not a modern invention! The ancient Greeks and Romans were skilled at color treating agates.

To turn a gray banded agate into varying shades of brown to black, the Greeks would soak the agate in a rich sugar solution. Agate's porosity is the key to the color change. The sugar solution soaks into the agate to varying degrees, as each band of the agate varies in porosity. After the agate has been well soaked, it is quickly rinsed and plunged into an acid, which will "burn" the sugar. The desired color is achieved by how long the agate is soaked in the acid. The acid decomposes the sugar, heat is released, and the sugar changes color in phases, starting with light tan and going through tan, brown, dark brown, and black when the sugar has been completely burned.

Metallic salts are used in a similar process to achieve the rainbow of colored agate: nickel salts for shades of green, chromium salts for orange to red, cobalt salts for blue to violet, iron salts for reds to yellows, and so on.

Nature doesn't use sugar and acid to color agate, but it does use metallic salts! Watery solutions containing varying amounts of dissolved metallic salts seep into the agates once they have formed. As the metallic impurities oxidize, they develop colors.

Not all agates are colored by outside invading solutions. Much more commonly, the original silica-rich colloids that form the agate are rich in metallic salts to begin with.

Chalcedony is cryptocrystalline quartz. It is usually 90 to 99 percent silicon dioxide with some water; salts of iron, aluminum and manganese make up the remaining percentage. It is important to note that chalcedony, including many agates, generally forms at lower temperatures than crystalized quartz. There are exceptions to both rules, though, as some agates form at high temperatures and quartz crystals have formed at ambient temperatures in plenty of cases.

It is now agreed that the vast majority of agates formed at or near volcanic action. They are most common in high-silica volcanics like rhyolite, andesite, and volcanic tuffs; the latter is a common source for thunder eggs and geodes. Each of these rock types is high in silica, the prime ingredient of agates.

These volcanic rock types are charged with trapped gases, which form small cavities as the lava cools. These open spaces are an ideal place for geodes and agates to form. Even after the lavas stop flowing, volcanic regions are hot enough to create hot springs, geysers, and the like. Think of Yellowstone Park, for instance. As hot solutions from the nearby volcanic activity percolate down through high-silica lava, they pick up silica, which can form a gel-like colloid when the solutions enter the gas cavities.

It is also possible that the magma contains small globules of silica gel or colloid that form agates as the magma lithifies. This theory of agate formation is not as readily accepted as the first, though there is supporting evidence.

Regardless of the source, the silica-rich colloid cools slowly in cavities locked within a hot mass of solid rock, which acts as a blanket. This allows time for agate development. As the colloid cools, it increases in viscosity, as the hot water cannot hold as much silica or dissolved salts in solution. Rocks like rhyolite are extremely sticky anyway because of their high silica content.

Gradually, the colloid becomes supersaturated, and crystallization must occur. That's when the fibrous quartz growth occurs and a band develops. As this is happening, some of the impurities present are squeezed out of the band and tend to form a boundary for the band that has formed. The residual metallic oxides give the new band color.

As a band forms, the saturation level of the colloid is reduced. But cooling continues, and eventually the colloid becomes supersaturated again and a second band forms. It, too, rejects impurities, and perhaps a different metallic oxide remains to give this band a different shade or color. Different minerals precipitate out of solution at different temperatures, so neighboring bands can be colored by different metallic impurities!

This process of cooling and banding continues either until the colloid is so dilute that no more bands form or until the temperature has reached some sort of equilibrium. The remaining solution, which is still fairly rich in silica, continues to cool, and euhedral crystals of quartz, almost always crystal clear and colorless, form in whatever space is left. This accounts for the small quartz crystals so often found in the center of an agate nodule.

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Chalcedony Agate *from page 83*

Tampa Bay, Florida, agate is really a chalcedony agate pseudomorph after coral that is colored by iron oxide.

The agate bands are still plenty hot, and they remain in a plastic state for some time. As euhedral crystals form in the center of the agate, heat is released. Internal pressures from trapped heat may cause the remaining solution to push outward toward any area of weakness in the banding. When this happens during the formation of the bands, this push drags the bands along, distorting them. This creates what we call "escape tubes," teardrop-shaped areas of banding within the agate. An escape tube may reach all the way to the agate rim, but usually does not. The narrow end of the teardrop points toward the perimeter of the agate, while the opposite end is more bulbous and closer to the center of the agate.

Escape tubes are not the only oddity seen in banded agates. Sometimes, bubbles form from trapped gases or from water vapor. Sometimes, an impurity is of high enough content to precipitate out to form a crystal of its own. This is why we see calcite, aragonite, siderite, and more often zeolite crystals in radiating clusters along the perimeter of the agate. Since zeolites form at low temperatures, some zeolite crystals will actually form in the gas opening before the agate forms. Other mineral species tend to crystallize out later, so they remain in solution to the bitter end of development. The radiating needle crystals we call sagenite are related to the arrowlike shape of some crystals. Sometimes, a single needle of a mineral like mesolite will form, and the agate forms around it to create a stalk. If we cut across the needle crystal, we see an eye. The needle mineral may later dissolve away, leaving an open-tube structure within the agate.

In most cases, the individual fortification bands in an agate are more or less uniformly colored, but not always. Some agates have red bands that will abruptly become yellow or orange! This is particularly common in agates from Argentina. This abrupt color change may be due to the chemistry of the impurity in the solution. Iron oxide can be red or yellow under certain conditions of temperature, which vary in agates, and manganese oxides can be violet or blue.

Another possibility is that the solution forming the color band is rich in more than one metallic oxide, iron and manganese, for example. If one metallic oxide is dominant, it can mask the second oxide. But as the first oxide is used up, the second oxide suddenly bursts forth, causing a distinctly different color in the rest of the band. There are undoubtedly other explanations—like changes in the pH factor of a solution and a sudden infusion of a second solution—for a band's abrupt color change.

Agates that have lovely dendrites, such as moss and dendritic agates, also have bands, but the bands remain more or less uniform in color—usually gray—due to the water content. As those bands were forming, they ejected impurities into the colloid. And like all minerals that approach crystallization, the molecules of the impurities, often a black manganese oxide mineral or red or yellow iron oxide, accumulated and formed a branching crystal growth we see as a dendrite or delicate mosslike growth. Sometimes, when the available oxygen is really limited, the metallic impurity may form a sulfide like pyrite first, and this may later change to an iron oxide with color. In a few cases, agates can actually contain bright pyrite or similar sulfide metal dendrites. I've even seen an agate with a small spray of native copper suspended in it. Some of the finest pyrite dendrites in agate I've ever seen are from the banks of the Agua Fria River, north of Phoenix.

Dendrites also occur after the agate forms when metallic solutions seep into a crack in the agate from the outside.

The moss in an agate often has a green tint, which causes some to think it must be an entrapped organic growth. Moss agate actually contains no moss, only an inorganic crystal growth that has formed in tiny filaments. Nickel oxide, among others, can take on a nice green color.

Various agate forms have been found in virtually every U.S. state, though the western states hold sway in most cases. One exception is the lovely agatized corals that have come from the northeastern arm of Tampa Bay, Florida. Colorful agate replacing coral has come to light during dredging operations. Some of the agatized coral is lined with bright yellow or red chalcedony agate, and other may be lined with banded or even black agate.

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Chalcedony *from page 84*

These agates, which are really agate pseudomorphed after coral, are very popular but are seldom collected these days.

Another unusual agate from Wyoming is called Turritella agate. An abundance of tapering, coiled snails were trapped in mud, which later silicified to form an attractive fossil agate. When cut and polished, the white-edged snail images are clearly visible and are certainly unusual.

People in the north central states can enjoy a summer's retreat on the shores of Lake Superior, where they can hunt for agates in the beach gravels there. These tend to be rather small, just an inch or two in diameter, but are a lovely banded reddish-brown. The Lake Superior agates undoubtedly eroded out of the submerged ancient volcanics of the area.

While Texas, Wyoming, California, Arizona, and South Dakota, to name a few states, all boast nice agates, this country's leading agate source is Oregon, particularly in the central part of the state. Here, rhyolite and high-silica igneous rocks occur in abundance, and each seems to yield its fair share of agate, geodes, thunder eggs, and the like. You can even find nearly colorless chalcedony geodes that are filled with water and slosh when shaken.

Superb thunder eggs are found in the Priday Ranch area; you can pay a fee for the privilege of digging for these reddish brown nodules with the star-shaped white interiors. You can also dig thunder eggs at Dugway State Park in Utah, an area set aside for rockhounds.

In southeastern Oregon, you can dig for wonderfully colorful plume agate, a form of agate also found on Powell Butte, near Prineville.

One of the better known sources for attractive chalcedony in Oregon is near Biggs, east of The Dalles, along the Columbia River. Called Biggs jasper, the material that occurs here is a volcanic ash flow that has been silicified by chalcedony, and can be cut and polished. The alternating light and dark shades of brown and undulating patterns and curves of Biggs jasper make very attractive designs in a finished piece. You see a lot of this material at shows.

Farther east in Idaho's Bruneau Canyon is a wonderful occurrence of picture jasper. This area was originally found by rockhounds! Occurring as rounded nodules and seam fillings, this jasper is a rich chocolate brown alternating with lighter brown and tan zones. The nodules are more or less rounded, so when domed and polished, the result is a lovely array of arching and curving color patterns in varying shades of brown and tan. Jasper

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Chalcedony Agate *from page 86*

is a chalcedony-type quartz materia, and is formed by the same microscopic fibrous crysta needles.

While America has its share of colorful banded agates, the most exquisite banded agates generally seen for sale on the North American continent are from northern Mexico. These have now been joined by outrageously colorful fortification agates from Argentina. Without any help from artificially induced metallic dyes, the Mexican and Argentinian agates have dominated the agate market for sheer beauty since the middle of the 20th century.

In the 1940s, superb banded agates were surface collected in the Mexican state of Chihuahua. The agates were found in several different areas, scattered over the eroded rhyolite, andesite and tuffs. These volcanics range in age from 28 million to 45 million years old, so they have been exposed to the elements long enough to be eroded even in this dry region.

Agates were found in a number of productive areas, which are named for nearby ranches or villages. They include Gallegos, Sueco, Agua Nuevo, Coyamito, and Laguna. All these sites are located on the east side of the main highway, the original Camino Real, which runs from El Paso, Texas, to Chihuahua City.

On the west side of this highway, crazy lace agate, Casas Grande agate, and several other lesser-known agate deposits can be found. Though their agates are very well known and admired, the Chihuahua agate areas have either been collected out or belong to ranches whose owners strongly discourage agate digging!

Still, one area in Chihuahua is not only very well known, but is still producing well. The area, around Cerro Mestano on the west side of the Camino Real, produces the "coconut" agate geodes, probably the best known and most frequently seen Mexican agates. The agate geodes occur in a deep zone of volcanic tuff. The region has dozens of mines and prospects, but the most important is probably Las Choyas, which produces huge quantities of the thin walled, virtually round geodes lined with quartz, much of which is dark amethyst. These geodes are regularly offered at mineral shows. The buyer can usually select a geode and see it broken open by the dealer. Some turn out to be just simple quartz-lined geodes, but others contain lovely surprises like wafer-thin calcite blades, dog tooth calcite, or small sulfide crystals.

The colorful banded agates of northern Mexico exhibit a great variety of soft pastel colors, along with a fascinating variety of internal features that challenge the scientist to explain how they formed. They include eyes, bubbles, crystal sprays, eunedra, quartz crystals, stalks, open tubes, pseudomorphs, and all sorts of bent and curving agate bands.

The flow of agates from the Chihuahua area is now only a trickle. The coconut geodes are coming out in tons, but the banded agates whose superb color and internal features have made them world famous are in very short supply now.

There are dozens of agate sources throughout the world, but except for Brazil and Argentina, little is being mined from any of them. The relatively new Argentina source is producing generous amounts of superb fortification banded agates sold under the name Condor agates.

The lovely banded agates of Argentina were first found by German geologist Dr. Franz Mansfeld in the first quarter of the 20th century (see "Argentina's Condor Agate," page 40, September 2005 *Rock & Gem*). He did little about the find, as his interest was in the fabulous banded rhodochrosite deposits at Catamarca in northwestern Argentina. He wrote the definitive study of this wonderful gem deposit.

Mansfeld's agate discovery was forgotten until the last decade of the 20th century, when Luis de Los Santos of Buenas Aires heard about it while visiting the rhodochrosite locality. Determined to find what were reputed to be superbly colored agates, Luis began a protracted search. He finally tracked down the agate fields, which have been producing absolutely gorgeous fortification agates whose colors are among the richest, most vibrant in agates found anywhere.

Condor agates are, for the most part, very nicely banded with a very limited number of oddities like stalks, bubbles, pseudomorphs and the like. Escape tubes are very common. Many Condor agates are also geodes, having central openings with bright clear euhedral quartz crystals.

The colors in Condor agates are their main feature. Superb fortification banding is enriched by brilliant reds, yellows, blues, and oranges. Some bands may start red and suddenly become yellow. These abrupt color changes, fairly common in Condor agates, add to their overall beauty and appeal.

The next time you go to a gem and mineral show, take special note of all the displays that feature one or more forms of chalcedony, including fine agate geodes, fortification agates, banded jaspers, delightfully carved agate objets d'art, and other lapidary creations. You'll agree with me that these very attractive examples of quartz are a mainstay of the lapidary arts and add much to the appeal of a good show. ❖

Rock Science

Steve Voynick

Probing the Frobisher Gold Fraud

Many *Rock & Gem* readers will recall Canada's 1997 Bre-X Minerals Ltd fraud, in which fraudulently inflated assay reports cost investors hundreds of millions of dollars. But Canada is no stranger to gold-mining fiascos.

The nation's first fraud actually goes back more than four centuries to 1576, when Queen Elizabeth I provided British navigator and explorer Martin Frobisher with two ships to search for the Northwest Passage. Near what is now Canada's Baffin Island, on a smaller island in the bay that now bears his name, the explorer found black rocks that, when heated, glittered with tiny goldlike specks. Frobisher's chemist performed fire assays, which seemed to confirm the presence of gold.

When Frobisher returned to England with samples, Elizabeth called in four prominent assayers to conduct additional fire assays. When one assayer recovered some gold from a sample, the queen provided three ships for a second voyage.

Frobisher returned to Baffin Island in 1577, this time sailing back to England with 200 tons of the black rock. But before the rock could even be smelted to positively confirm any gold content, Elizabeth, filled with visions of replicating the recent Spanish acquisitions of New World gold, gave Frobisher 17 ships for a third voyage.

The following year Frobisher filled the holds of his fleet with 1,200 tons of the black rock. By the time the ships returned to England, the queen had already ordered construction of large furnaces at Dartford, near London, to smelt the "ore."

But when the new furnaces produced not a speck of gold, the resulting scandal shook all of England. Since then, historians have speculated about what really happened. Was Elizabeth and her court conned, or did the assayers really believe that the black rock contained gold?

In 1981 and again in 1990, the Smithsonian Institution sent expeditions to the Baffin Island site to learn that Frobisher's "gold ore" was actually a metamorphic rock loaded with fine crystals of black hornblende and flecked with bits of biotite mica. When heated, the biotite oxidized into tiny, gold-colored flakes, which inexperienced or over-eager eyes might possibly mistake for gold. Modern spectrographic analysis also determined that the black rock contained nothing more than normal, geochemical background traces of gold.

But what of the English fire assays? Fire assays in the 1500s were generally similar to those performed today. Assayers heated carefully weighed powdered-rock samples in ceramic cups, then added powdered lead. The lead melted and a geochemical affinity bound it to any gold and silver present. The assayers collected the lead "buttons" that formed at the bottom of the cup and chemically separated any precious metals. The weight of the recovered gold or silver was a direct and usually accurate indication of the richness of the original rock samples.

One Canadian mineralogist theorized that Frobisher's chemist unknowingly used lead that had been contaminated with gold from previous assay work, and thus the scandal resulted from nothing more than innocent error.

But in 1993, an archaeologist from Canada's Laval University excavated the Baffin Island site to recover five lead assay buttons produced by Frobisher's chemist. Recently, electron-probe and mass spectrometer analyses have revealed that these lead buttons contain no gold at all.

"With these results we've now discarded the possibility that the lead was contaminated with precious metals," Laval University archaeologist Dr. Reginald Auger recently stated after reconsidering all the data. "The chemists at the site must have known the ore was worthless."

"We can only conclude," writes Auger and his Laval co-researcher, geologist Dr. Georges Beaudoin, "that the gold was added by the assayers in London." Beaudoin estimates that just 2 ounces of gold would have been enough to salt Frobisher's samples and launch an Elizabethan-era investment frenzy.

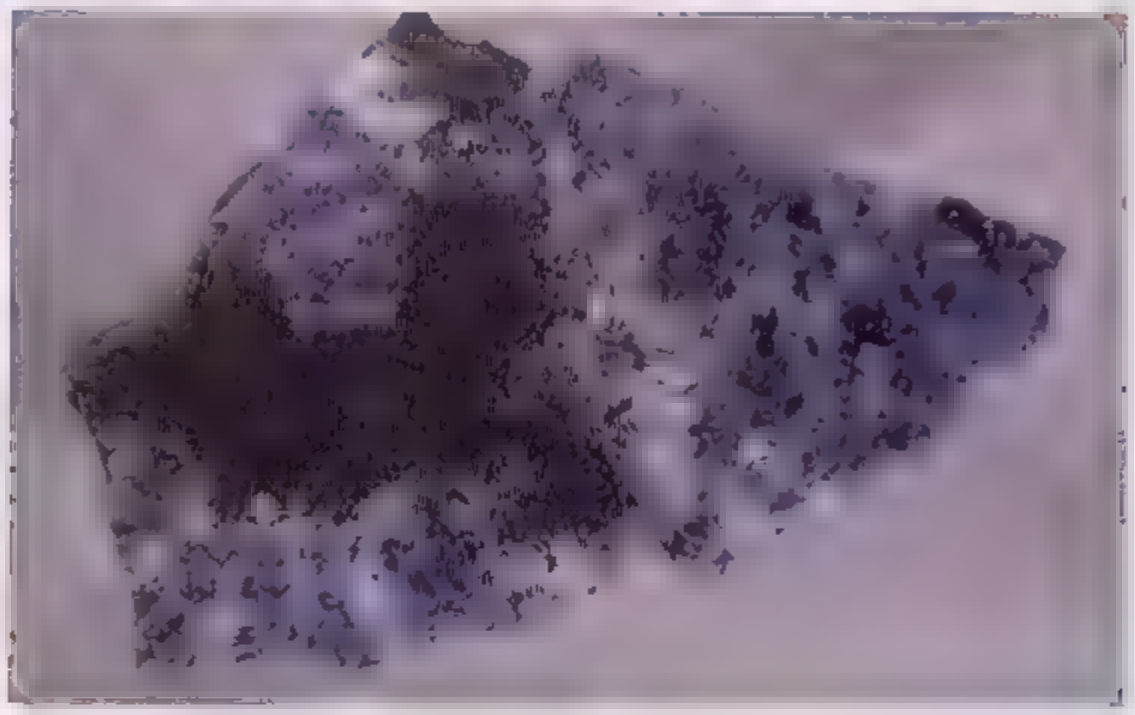
Thanks to modern geochemical sleuthing, most historians now agree that Martin Frobisher's Baffin Island "mine" was Canada's first gold-mining fraud, although Frobisher himself may have been unaware of it. Now historians are trying to identify the likely perpetrators and what motivated them.

FIELD TRIP

Princess Sodalite

This Regal Blue Mineral Can Be Picked Up for a Song

Story by Pat Kerr / Photos by Dan Kerr



Blue sodalite, here with black tourmaline and magnetite, can be confused with lazurite and lazulite.

A sodalite sphere (top center) is on display at the Bancroft Chamber of Commerce along with associated minerals like rose quartz, feldspar, pyrite, apatite and cancrinite.

Princess blue sodalite inspired a princess when she was decorating a castle, and yet this stone still sells for $1.50 a pound at the quarry site. But I found my best samples at the free collecting sites outside of Bancroft, Ontario.

In North America, blue sodalite is found along the York River in Ontario, in Litchfield, Maine, and in Ice River, British Columbia. In the Bancroft area of Ontario, three sites are recommended for free collecting. They are all within hiking distance of each other.

The name sodalite alludes to the mineral's sodium content. It was discovered in Ontario in 1891 and shown at the World Exposition in Chicago in 1893, but it wasn't until a sample was given to a British princess in 1901 that it became famous. Legends abound about this gift, though I was unable to confirm their truth. We do know she took 130 tons of the stone back to Britain and used it to decorate Marlborough House in London. The building now houses the Commonwealth secretary. In recognition of this royal favor, the deposit was renamed the Princess Sodalite Quarry.

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According to *The Natural History of Ontario* (McCleland & Stewart, 1989), Helikian sediments and volcanics from about 1.3 billion years ago are now found in places from the St. Lawrence River to Haliburton, Ontario. It is believed that the rocks were intruded by massive igneous rocks and uplifted, then erosion removed the mountains and the ancient crust was exposed. Today, mineral collectors prize the highly metamorphosed rocks. Bancroft is in the southern portion of the Grenville Province of the Canadian Shield, a crustal formation dating from the Precambrian Era. Specifically at this site, nepheline rocks were infused with sodium chloride, which gave the rock a deep blue coloring.

From Toronto, take Provincial Highway 401 east to Route 115, following Route 115 north and then northeast past Peterborough to Trans-Canada Highway 7. From Trans-Canada Highway 7, turn north again on Provincial Highway 134 and continue northeast on Provincial Highway 28 into Bancroft.

While in Bancroft, you can stop at the Chamber of Commerce, housed in the old train station. It sells maps of the local free- and fee-collection sites, rents tools and topographical maps, and has a mineral museum that you can tour for a donation. Watch for the signs in the town for the sodalite mine shop, and stay on Provincial Highway 28 for 2.3 miles (3.7 kilometers) from the center of town. The trail to the collecting site is on the south side of the road just before the sodalite mine, and it is not marked. We drove in with a four-wheel-drive pick-up, but most cars could access it without difficulty. Large recreational vehicles and trailers may want to drive ahead to the sodalite mine store and ask permission to park on their property.

As you travel from Toronto to Bancroft, you will pass through several geographical zones. At Toronto, you should see gray shale and limestone beds. Around Pickering, look for gray and black shale. When you are north of Lake Scugog, the geology is limestone, and finally, north of the Kawartha Lakes district, you will see Precambrian Shield. If you stray off the direct route, you will notice escarpments left by the receding ice sheets. Ontario's first diamond was found in the Peterborough area on one of the many escarpments. In the summer, there is always road construction along this route, so if you have time, stop and explore.

Large samples of pink and blue sodalite are available in the Bancroft area and can be collected using a sledgehammer.

There is a grassy area about 100 feet up the lane where we parked, and we hiked from there to the collection sites. South of the parking area is a swampy pond. We walked across the field toward the pond and passed a fallen-down cabin. In low-water times, the pond is easy to cross, as someone laid boards and logs out, but in the spring, fall, or damp years, you will get your feet wet. It would be accessible with an ATV.

Past the pond, the trail takes several branches; each will take you to a different collection site. I suggest that you carry water, a snack, and bug repellent, and be bear aware in this area. The hike is gorgeous in all seasons, but you are requested to avoid it in the fall deer-hunting season. Information about the deer hunt dates is available annually from (800) 667-1940 or at www.mnr.gov.on.ca.

The Lily Robertson site is accessed by the first fork to the right off the trail. Here, we found a cliff face with extensive evidence of pounding. The rock contains corundum-bearing nepheline, and apparently that is what collectors were seeking. A sledgehammer is needed at this site. I carried nothing from this area, but I am confident that, if you are energetic, there is lots more to be found.

The Cancrinite Hill site was reached by the second fork to the left off the trail. We found dark-blue sodalite in nepheline about halfway up the hill. A hammer and chisel are useful at this site. Broken pieces were found at the bottom of the slope.

As always, the best collecting site required the most effort to find. Davis Hill is a steep climb on a hot day. To get there, take the first fork in the trail from the pond and then take the next fork to the right. The trails are well marked and there is little danger of getting lost if you stick to the paths, but if you want the best samples, you will have to leave the trail. Carry a compass and know how to use it. This is a large, vacant, wooded parcel of land. Don't take chances.

Books of biotite and other related minerals can be found at the sodalite sites near Bancroft.

At the top of Davis Hill, we found evidence of animal baiting and heard hunters target practicing. We and our dog wore orange protective clothing for safety, and we always carry bear spray in this region. We found nothing at the top of the hill, but further exploration around the side revealed areas that had been blasted to assist collectors. This is a dream site. We found tourmaline, pink zircons, magnetite, pyrite, apatite, books of biotite, and the blue sodalite I was seeking in veins deep enough and large enough to produce specimens to display in my garden.

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On The Rocks

Turquoise Is on the Rise

The December issue of *Rock & Gem* featured that month's birthstone, turquoise. That lovely copper gemstone is experiencing a wonderful renaissance. Not only is turquoise jewelry once again popular, but its sky blue color is taking over the fashion industry.

Turquoise ranks as one of the oldest gems ever collected, dating back 4,000 or 5,000 years at least. After thousands of years of cultural history, turquoise has been on a rollercoaster ride in recent decades, reaching a pinnacle in the 1970s and then fading into the background of the jewelry market. Now, I'll bet turquoise miners and craftsmen are walking around saying, "It's *ba*-aaack!"

Its popularity has certainly impacted the value of the stone. Even stabilized turquoise has gone up in wholesale value. In some cases, the wholesale price has doubled and even tripled. The price of untreated natural gems, which was always at a premium anyway, also reflects its scarcity and the recent increase in popularity.

The last time turquoise hit the big time was when an Eastern publication said it was a good investment. Suddenly, every tourist who visited New Mexico or Arizona just had to buy something made with turquoise. Native American jewelry was suddenly at a premium, while nugget necklaces, bola ties, bracelets, rings, and carvings quickly sold.

Every rock formation that had ever given up a bit of turquoise was instantly staked and mined. A host of companies began to stabilize the poorer turquoise to satisfy the immense demand for this blue gem. As the natural stone became more difficult to mine, the supply was supplemented more and more with pseudoturquoise, any stone that could be made to look like turquoise. For instance, snow-white howlite, which doesn't even contain any copper, is easily dyed to look like turquoise and was suddenly available in gorgeous blue.

Worthless white, chalky turquoise, too soft to be used for anything, was being infused with anything to give it color and hardness. Properly stabilized and hardened turquoise is excellent lapidary material, but some of the early methods were almost worthless. These early scams were easy to detect if you knew real turquoise. One way was to stick a red-hot pin into the rock purported to be turquoise. The pin would melt the plastic, and a distinctive odor would tell the tale.

Imagine the degrading effect all this chicanery eventually had on the turquoise market. It didn't take buyers and investors long to realize the market was destabilizing as it was rapidly being saturated with fake turquoise jewelry and synthesized turquoise.

Other jewelry was made in parts overseas, say in the Philippines. The partially assembled jewelry would be shipped to the United States, where a Native American worker added the final piece. Thus, the piece could be offered as authentic Native American work. Eventually, laws were passed to protect the native art form in hopes of stopping the selling of non-Indian work as authentic. Unfortunately, this is still a practice in the industry today.

During all this hoopla for turquoise and Native American jewelry, a small group of really talented Native Americans gained much-deserved recognition. Not only did they hold to traditional Native American designs, they used them to achieve a level of creativity that gained them recognition and a strong following for what has been a modern evolution of Native

Carl Clark is one of the Native American artists whose jewelry gained popularity from the 1970s turquoise craze.

American jewelry art. The stunning creative work by some of the top Southwest artists gained popularity in spite of all the negative events going on around it. By maintaining the integrity of their work and their Native traditions, these artists are still producing some of the most beautiful turquoise pieces ever imagined. So while the market was depressed, these artists surfaced, as gallery owners who really knew fine work did their best to keep them working and creating.

Today, these talented artists have their work featured in museums and offered for sale in the finest galleries in the Southwest. So, there has been a thin, but strong, thread of success linking the turquoise market of yesterday to today. Now the lovely color of turquoise has come back in fashion, with a corresponding surge in the sale of turquoise jewelry.

All the major turquoise deposits in this country have been worked almost to exhaustion. Bisbee, Pinto Valley, Globe, and Miami, Arizona, along with several major deposits in New Mexico, have been major sources of the blue gem in the past. Most are copper porphyry deposits, the most common good source of turquoise, a hydrous copper phosphate. The copper obviously comes from the breakdown of the copper minerals in the ore deposit, which is often intruded into the surrounding granitic rock.

Nevada is an even more important source of turquoise, but again, many of its deposits have been mined to the point of exhaustion. Luckily, Mexico and China have come on board big time, so watch for their lovely blue stones. How long this latest turquoise popularity will last is hard to predict, but you can be sure turquoise will always remain one of America's treasured gems.

* * *

One of the great shows on the East Coast is the East Coast Gem, Mineral and Fossil Show, held on the Eastern States Exposition Grounds in West Springfield. The facility is locally known as the Big E. The East Coast Show always features a significant collection as its main theme. A few years ago, I hauled two of Arizona's finest mineral collections, owned by Les Presmyk and Evan Jones, back there. Show promoter Marty Zinn sees the wisdom in bringing collections to the show that would otherwise not normally be seen by the general collector population.

In 2005, the featured collection came from the Harvard

University Museum and was a remarkable assemblage of both historically important and uncommonly fine recently discovered minerals. Put together by Curator Carl Francis and his assistant, Bill Metropolis, the collection featured pieces of the museum's superb gold collection. The core of this collection was put together by A.C. Burrage, who had been able to obtain both the William Blake collection and the de Buglise collection, each one rich in choice crystallized golds.

I was particularly pleased to see a fine selection of elbaites from Connecticut's old Gillette Quarry, one of my old collecting sites. Two cases of barite—a fine one from Germany and an impressive selection of England's finest—were a sight to behold.

I particularly liked the displays that featured specimens from collections once owned by noted mineralogists and collectors like Andres Karabacek, Charles Holden, and others whose names you see in the literature. The Harvard display highlighted fine minerals from Vermont, Connecticut, Massachusetts, Maine, New Hampshire, and Rhode Island. It was a credit to that institution, and those who put it together certainly deserve our thanks.

* * *

In my September column, I told about my run-in with Pele, the Hawaiian goddess of fire. I'm sure some readers scoffed at the idea that Pele curses anyone who messes with her volcanoes. Reader Frank Huff, however, is a firm believer, thanks to an adventure he and his wife had!

Frank was born in Hawaii and lived there for 25 years before moving to California. On a visit to the islands, he and his wife decided to drive from Kona to Hilo across the Kau Desert, a vast lava flow. During the drive, Frank stopped the car and walked over to the edge of a ravine to admire the view. A sudden gust of wind blew his hat off and sent it down into the 150-foot-deep ravine, so he climbed down to get it.

As he was climbing out, he picked up a wonderful example of pahoehoe lava with a teardrop shape in the middle of the piece. As he got into the car, another gust of wind blew the car door shut—right on his fingers! As they drove toward Hilo, Frank's big toe began to throb. It had developed a huge blister from the climb into the ravine. There were also small cuts on his feet from climbing lava in his flip flops.

As they continued driving, Frank's wife suddenly had an attack of diarrhea with no facilities in sight. They made it to the Kilauea Lookout facility too late, and besides, there was no toiletpaper! Still, they enjoyed seeing the Halemaumau eruption, then continued toward Hilo, only to run into a heavy rainstorm that had not been predicted. The rain was so heavy they could hardly see. When they decided to turn around and head back to Kona, they got a flat tire. Frank had no choice but to change the tire in a heavy downpour!

Back in Kona, Frank made arrangements to have the purloined lava beauty returned to Pele's domain! Frank says, "Pele lives!" He should know!

One of the things you can pick up in Hawaii is lovely coral jewelry. We usually think of coral as being pink or red, but black coral jewelry is gaining in popularity. After all, it is the official state gemstone of Hawaii!

Like so many popular gemstones, including turquoise and coral, there is a finite limit to what is in or on the Earth. As popularity for a particular gemstone like coral increases, a fear arises that the supply will eventually diminish.

To prevent that, the Scientific and Statistical Committee of the Western Pacific Fishery Management Council (WPFMC) recommended that coral harvesting be banned for five years to give the creatures time to develop. The WPFMC modified the committee's recommendation and restricted the harvesting of coral to anything 20 years or older. This gave younger growths a chance to develop and reach a useful size! You can't ask a coral branch how old it is, but you can measure its base, which should be at least a inch thick after 20 years of growth.

Large natural turquoise nuggets are harder to find these days, so their value has really increased.

Black coral, known as ekeha-ku-moana, is just one of four species of gem coral found in the island waters. Most coral is made partly or completely of calcium carbonate. Black coral, however, is made of conchiolin, the organic stuff oysters use to make pearls. Hawaiian black coral is found in the Auau Channel between Maui and Lanai at depths ranging from 100 to 200 feet. It is largely collected manually using scuba gear. Coral species that occur at depths well over 1,000 feet have to be harvested using minisubs.

The black coral business in Hawaii brings in some $30 million dollars a year, so it was significant that the WPFMC chose not to declare an outright ban. The most active coral mining group in Hawaii is the Maui Divers, which originated coral harvesting over 40 years ago. This group supplies most of the coral used in the jewelry industry.

Though coral is a very beautiful gem, it does have some drawbacks, such as a lack of significant hardness. It is Mohs 4 at best and can be scratched if worn in jewelry or exposed to the elements. It is traditionally used as beads in necklaces and sometimes in bracelets. It is also used as small inlaid gemstones to contrast with more colorful stones.

* * *

The big winter event in Tucson is drawing closer. Would you believe more than 40 different shows are scheduled for 2006? Most of them are wholesale and feature gem and lapidary rough and lapidary supplies. At some wholesale shows, there are so many piles of faceted gems for sale I think the city could pave the main floor of the Convention Center with them!

Luckily, there are enough public shows to satisfy every rockhound and mineral collector. A lot of the motel shows are open to the collecting community, offering some great mineral and lapidary dealers. Of course, the premier show is still the Tucson Gem & Mineral Show in the Tucson Convention Center, Feb. 9-12.

The show is preceded by an evening reception in the Tucson Convention Center on Wednesday, Feb. 8. The reception starts at 6:30 p.m. with fine refreshments, a top-notch speaker, and a chance to socialize with your collecting friends and hobby leaders. I'll give the reservation number in next month's column. See you there!

Princess Sodalite *from page 98*

The sodalite is in light-gray nepheline syenite. As expected, I didn't find any crystals, just architectural stone. It is glassy and has a hardness of Mohs 5.5 to 6. The term sodalite refers to the mineral's sodium content. If sodalite is dissolved in HNO_3, the solution will give a positive chlorine reading to a swimming pool test kit; sodalite is the only feldspathoid that contains chlorine.

Blue sodalite is usually only confused with lazurite and lazulite. The textbook says it is usually not associated with pyrite, but lazurite is associated with pyrite. Sodalite is also not associated with quartz. According to the Amethyst Galleries' Mineral Gallery Web site (http://mineral.galleries.com/minerals/silicate/sodalite/sodalite.htm), if quartz was present "when the melt was crystallizing, it would react with any feldspathoids and form feldspar." Another test for sodalite is the hydrochloric acid (HCl) test; it will dissolve sodalite and leave a silica gel.

In other areas, pink sodalite is found. This is differentiated from hackmanite by its SO_3 (sulfur) content, and by the fact that hackmanite is highly fluorescent.

The nepheline syenite is a gray-white stone that is granitelike in texture, but contains no quartz. At a glance, it resembles quartz, but it is softer and has a greasy, not glassy, luster. Noting the absence of quartz is a major indicator that what you have found is blue sodalite, not lazurite.

Lazurite is not found in Ontario. It is found in California, New Hampshire, and Georgia. It only dissolves slowly in hot acid. The associated minerals are wardite and brazilianite. It is the same hardness as sodalite, Mohs 5.5 to 6, but it fuses with glass.

Back at the truck, we made the short drive to the Princess Sodalite Mine Rock Shop. The shop is open only during the summer, and the quarry is closed to visitors all year. The mine started working in 1906 and continues producing architectural stone.

We signed a permission slip at the store and were allowed to explore the "rock farm." Admission is free. The rock farm is a man-made area behind the store that is restocked twice per year with rock quarried predominately from the area, but you can—and I did—find some surprises, as the owner will dump collections from the area when they are available. I found little sodalite, but in minutes I had collected gem-quality apatite, rose quartz, dark amethyst, feldspar, and magnetite. Almost every mineral available in the Bancroft area was in that pile for the easy picking. Collectors pay $1.50 Canadian per pound (approximately $1.13 US) at the store.

The side of the Davis Hill collecting site has been blasted to help collectors retrieve samples of tourmaline, biotite, zircon, magnetite, pyrite, apatite, and blue sodalite.

The rules are simple: no open shoes and no sledgehammers for safety reasons. Rockhounding hammers and chisels are acceptable, but not necessary. Pieces vary in size from museum size to minuscule.

Andy Christie, owner of the sodalite quarry and rock farm, started visiting in the area around 1970. What started out as a hobby became a passion, and finally a full-time business. He worked as a dealer at the local Gemboree for 17 years and finally purchased the quarry. He now wishes he'd moved here 10 years earlier. "I'm a Bancroft man," he says. Andy is the ninth owner of the quarry. Its colorful history includes ownership by the British Crown and the Department of Mines.

The sodalite in his mine is, as usual, in seam deposits from 2 inches to 2 feet wide in the nepheline. There is a neighboring house only about 50 feet from the quarry, so only professionals are allowed to blast in the area. For the most part, Andy works alone or with friends, using "feathers and wedges" to release the stone. He drills holes with a 1¼-inch-diameter carbide bit about 6 inches apart. Two pieces of steel (the feathers) are inserted and a wedge or chisel is driven in. As he works along, a crack appears, and he can hear "funny noises." Then the face will fall away. Always hoping for the mother lode, Andy persists, using primarily sweat, as blasting damages the stone. The manual labor required to mine sodalite is what keeps the price high.

Andy insists that pyrite is found with the sodalite on his property, although not always, but he says you can tell the difference with the naked eye between lazurite and sodalite. Lazurite has a deeper color and finer grains, and is more opaque.

The store contains the standard assortment of minerals and fossils. It also carries handmade sodalite and silver jewelry and sells tumbled and cut sodalite beads. Andy used to do the cutting and turning on site, and he still has the equipment and is happy to discuss his techniques with visitors. However, he now sends the stone to China for carving and polishing, as it is cheaper. This year, visitors have arrived from as far away as Iran, Germany and Italy. Thousands will visit by the end of the season. Although Andy has had several retail locations over the years, he now only markets through his store in Bancroft.

The stone that wowed a princess and graces a palace found a home in my garden, and beads collected in Bancroft and polished in China will soon be presents for our kids. It is said that sodalite will foster harmony, courage and communication for those who wear it. Sounds like something we all can use.